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CONTROLLED EVALUATION OF THE REACTIVE ENVIRONMENTAL SIMULATION MODEL (REM)

VOL. 2

USER'S GUIDE

PACIFIC ENVIRONMENTAL SERVICES, INC.

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

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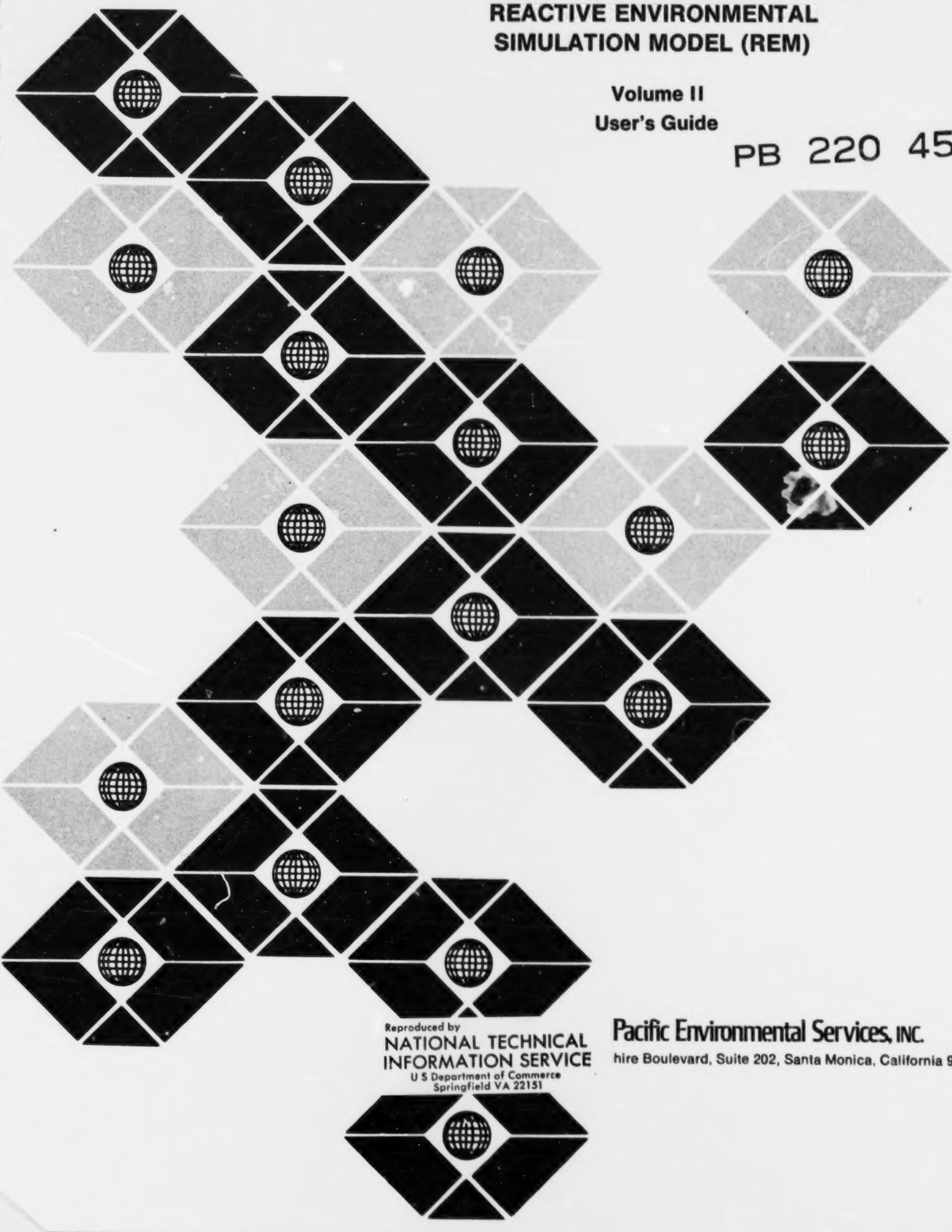
Volume II

User's Guide

PB 220 457



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The report describes the design, operation and use of the Reactive Pollution Environmental Simulation Model (REM). Its main purpose is to explain to the user how REM functions and from experience gained in operation, how it can best be utilized. The report thus includes imparting to the user the following: (a) detailed instructions for setting up input decks; (b) how REM may be utilized in performing control strategies; (c) an understanding of the methodology, techniques and calculational procedures employed in REM; and (d) sufficient information to enable program modifications to be accomplished. The above tasks are facilitated by the incorporation of algorithm descriptions, flow charts, complete data input instructions, sample input decks, a glossary of program terms and program listings in this volume.

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VOLUME II: USER'S GUIDE
EPA R4-73-013b

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Section I
Introduction

This document describes the design, operation and use of the Reactive Pollution Environmental Simulation Model (REM). Its main purpose is to explain to the user how REM functions and from experience gained in operation, how it can best be utilized.

The latter includes imparting to the user the following:

- Detailed instructions for setting up input decks;
- How REM may be utilized in performing control strategies;
- An understanding of the methodology, techniques and calculational procedures employed in REM; and
- Sufficient information to enable program modifications to be accomplished.

The above tasks are facilitated by the incorporation of algorithm descriptions, flow charts, complete data input instructions, sample input decks, a glossary of program terms and program listings in this volume.

Section II

Description of the Reactive Environmental Simulation Model (REM)

A. INTRODUCTION

The REM effort has been directed towards the construction of a sophisticated photochemical mechanism which is capable of closely replicating smog chamber data and then extending this capability to the urban atmosphere. REM is based on a Lagrangian (moving coordinate) system. This system enables the numerical computation of the chemical reactions to take place in a moving parcel or column of air. The parcel is bounded by the inversion base above and the ground below. The locations of the base of the column at successive points in time describe the path or trajectory that the air parcel traverses across the region. The trajectory is computed by special routines contained in the REM program from wind velocity information contained in the data base as a function of time of day and location. An overview of the model's operation is presented in Figure II-1.

The computer program has been designed as a detailed episode mode for chemical kinetics, with additional modules linked up to form a complete atmospheric system. The modules presently in the system determine the necessary meteorological parameters, the rate of absorption of actinic light by NO_2, and emissions due to traffic and area sources. A schematic diagram of REM appears in Figure II-2. The facility exists to incorporate modules to calculate the emissions due to large point sources and the effect of vertical diffusion should practical and effectual methods be found to perform these tasks.

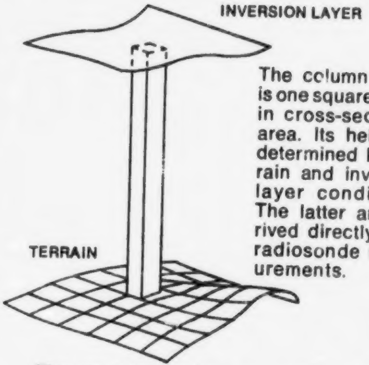
II.2

PHOTOCHEMICAL MODELING

For pollution modeling, the air space within each geographic grid is assumed to emit an approximate mean value of pollutants for a given time. The model includes nitrogen oxides, high and low reactive hydrocarbons and carbon monoxide. Values are provided by local environmental control agencies.

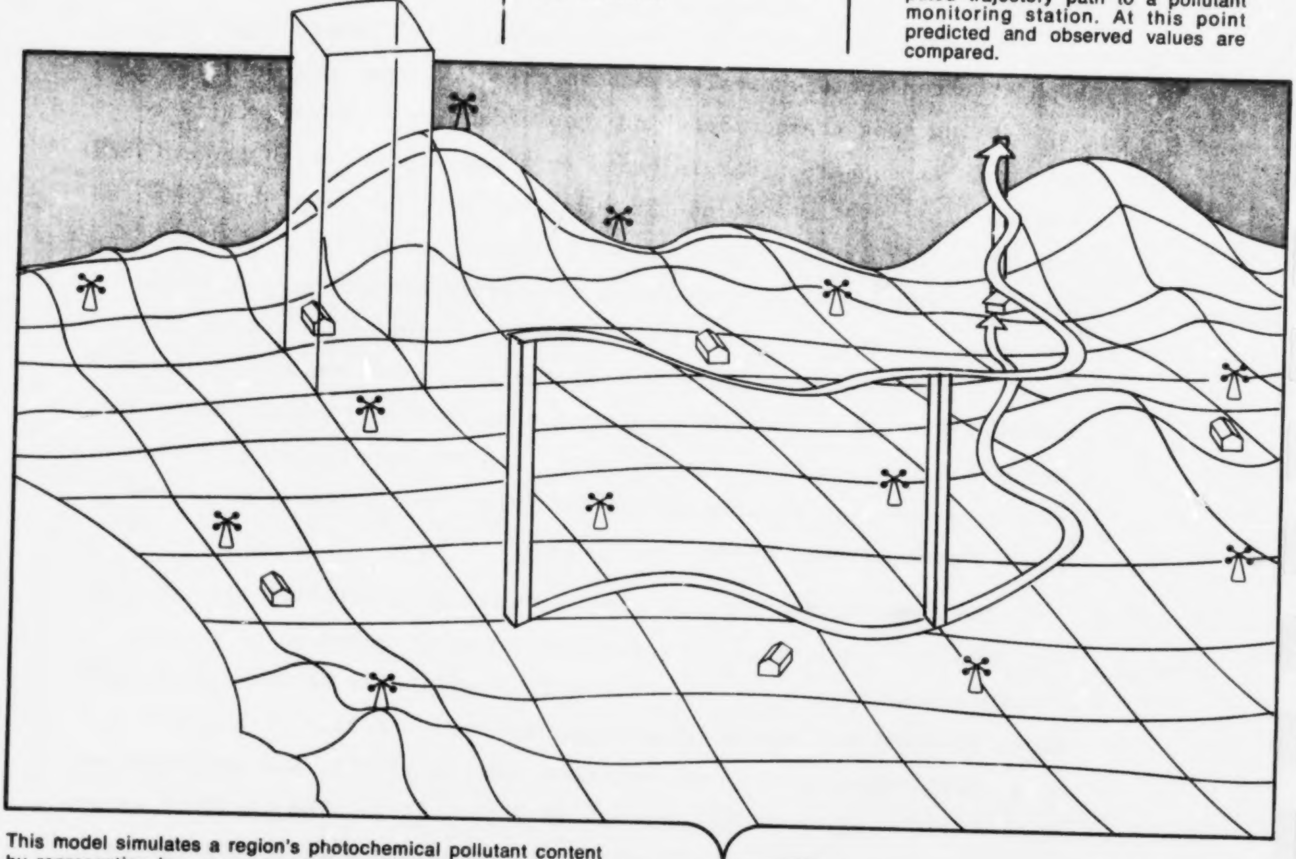
Meteorological stations provide current data on winds, temperature, pressure, dew point, etc., to the model for predictive movement of air parcels through the various grids.

Pollutant monitoring stations measure types and amounts of pollutants, i.e., oxidants, hydrocarbons, nitrogen oxides, carbon monoxide.



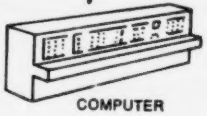
The column of air is one square meter in cross-sectional area. Its height is determined by terrain and inversion layer conditions. The latter are derived directly from radiosonde measurements.

The model predicts the amount and type of photochemicals present in a column of air as it traverses a computed trajectory path to a pollutant monitoring station. At this point predicted and observed values are compared.



This model simulates a region's photochemical pollutant content by representing in a computer the chemical reactions occurring in a column of air as it traverses a dynamic wind trajectory. The model is tested by acquiring appropriate meteorological and pollutant data from a dense network of monitoring stations.

The path of a moving parcel of air is computed on the basis of wind station data. As the parcel passes over the urban area it picks up pollutants from vehicular traffic, power plants, factories and other sources. Pollutants, or emission rates, for each grid are contained in the data base. With the sun's energy acting as the catalyst, the pollutants are transformed into a variety of photochemical pollutants, producing the well known effects of smog. Predicted concentrations for these pollutants are printed out for points along the air parcel path and compared with values measured at actual air monitoring stations.



In a given area this photochemical model could predict the effects of new smog control devices for any given time period after introduction, determine a proposed freeway's effect on pollutant concentrations, or the contributory effects of new industries and proposed rapid transit systems. Decreases in pollutants that would result if modified or advanced propulsion systems are used in vehicles or if nuclear power plants are installed also could be predicted by the model.

Figure II-1. PES Reactive Environmental Model (REM)

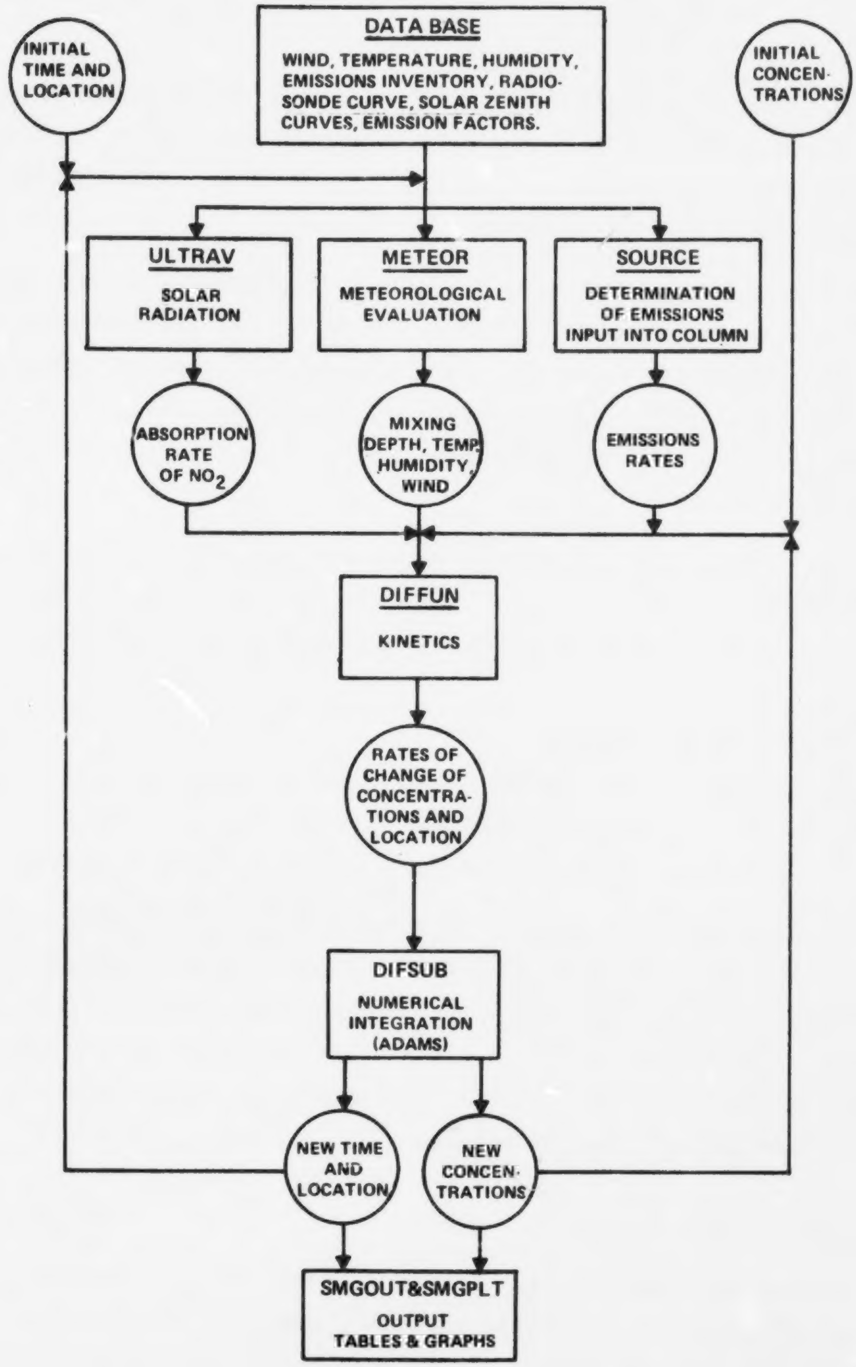

DATA BASE
WIND, TEMPERATURE, HUMIDITY, EMISSIONS INVENTORY, RADIOSONDE CURVE, SOLAR ZENITH CURVES, EMISSION FACTORS.
INITIAL TIME AND LOCATION
INITIAL CONCENTRATIONS
ULTRAV
SOLAR RADIATION
METEOR
METEOROLOGICAL EVALUATION
SOURCE
DETERMINATION OF EMISSIONS INPUT INTO COLUMN
ABSORPTION RATE OF NO2
MIXING DEPTH, TEMP, HUMIDITY, WIND
EMISSIONS RATES
DIFFUN
KINETICS
RATES OF CHANGE OF CONCENTRATIONS AND LOCATION
DIFSUB
NUMERICAL INTEGRATION (ADAMS)
NEW TIME AND LOCATION
NEW CONCENTRATIONS
SMGOUT&SMGPLT
OUTPUT TABLES & GRAPHS

Figure II.2. Schematic of the PES Reactive Environmental Model (REM)

B. GRID SYSTEM

The geometric setting for REM is a standard two-dimensionsl coordinate system. REM utilizes the mile as the standard unit of measure with all urban grid squares chosen as 4-square miles. The kilometer can also be used as the standard.

To set up the grid system, the origin is placed at a point such that the region of interest resides entirely in the positive quadrant. The coordinate positions of all air monitoring and meteorological stations are established in either miles or kilometers. These values are then fed into the model at execution time. In this manner, REM can be applied in any region.

Figure II-3 illustrates the grid system used by REM for the Los Angeles Basin. The locations of the air monitoring stations are designated as circles and the coordinate points are given in miles.

C. PROGRAM CODE AND MACHINE USE

REM is coded in the FORTRAN IV computer language and has operated with both the Level G and H compilers. It is thus operational on any computer system with 150K in core and a standard FORTRAN compiler.

The Los Angeles validation version of the model has been successfully run on the IBM System 360, Models 50 and 65, and the IBM System 370, Models 155 and 165. The ratio of simulation time to computer time used was approximately 150:1 on the 370/155 and 550:1 on the 370/165. In regions where much less data is available than in Los Angeles, REM will operate at even greater speeds.

D. OPERATION OF REM

REM has been designed to operate as a multi-receptor point model. The user is required to provide a minimum number of inputs after the data base has been prepared. In its execution mode, the model transports a parcel of air, bounded by the ground and the inversion layer,

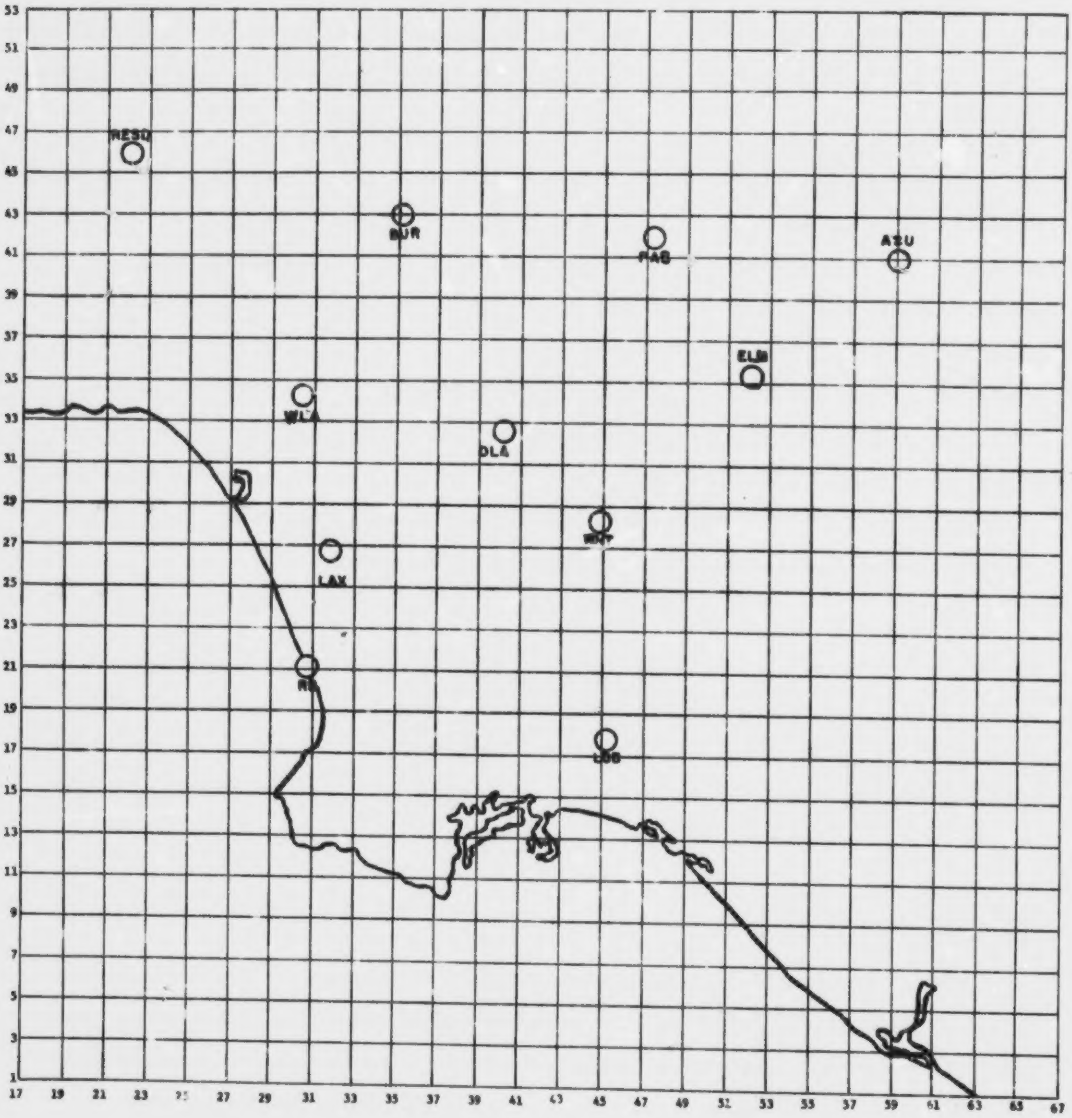


Figure II.3. REM Grid System for the Los Angeles Basin

along a dynamic trajectory that is generated utilizing wind data from numerous meteorological stations. At each point along the path, the speed and direction of the trajectory are recalculated.

The user may select the starting point or the terminus for each simulation run. In either case, he must indicate the length and starting time (of day) of the simulation, and initial values for the major pollutants.

If the user selects the terminus, he must first operate the reverse trajectory program (see Section F.10) to determine the correct starting position and major pollutant values. The starting location is necessary because this point must be input into REM in order for the trajectory to reach the selected terminus at the end of the full simulation run. The initial pollutant concentrations are determined by interpolation of observed values at air monitoring stations to the trajectory starting point. Once the location and starting values have been calculated for a simulation run, the same trajectory may be run many times over without utilizing the reverse trajectory program again.

If the user executes the model by selecting a starting point, he may wish to choose a monitoring station where the initial pollutant values will be known. As an alternative, he may select another point of interest, or pick a completely random location. For these latter cases, some assumptions may be made regarding the starting values, or minimum or standard background values may be input.

E. CONTROL STRATEGIES

After a given full simulation run has been made, it may be considered as a standard run for the purposes of evaluating particular control strategies. Control strategies are implemented to reduce pollutant concentrations and to attain required air quality standards.

By varying any of the numerous emissions inputs to the REM, either individually or in combination, the possible effects of control strategies can be determined before they are actually implemented. These strategies may include for example: reducing total traffic, reducing traffic in specified areas, reducing emission rates, varying traffic patterns, or altering operating times of area sources.

F. REM MODULES

The modular construction of REM has facilitated the model's development and alteration, when necessary. Any given module may be unplugged and replaced as desired; or special modules may be created and added to handle special situations.

1. Initialization Program

The initialization program reads in the data base and the information needed for a complete simulation run. This program converts all of the data, except station locations, to the metric system for easy utilization by the other modules, and calls the numerical integration, output and plotting routines as required by monitoring the simulation time. At the end of the run, it checks to see if another simulation is to take place. To make additional runs, only control information must be input thereby facilitating the operation of REM for the user.

The initialization routine outputs the data base that has been read in to provide the user with a permanent record of the information employed in the simulation. A complete list of the data categories required for input follows:

- Trajectory start position and time of day;
- Length of simulation;
- Starting pollutant concentration values;

- Control parameters for numerical integration routine;
- Meteorological stations - location and elevation;
- Meteorological variables - hourly data (wind speed and direction, temperature, dew point);
- Emission factors for freeway and street traffic in grams per vehicle mile;
- Grid distribution of hourly area emissions;
- Radiosonde data - temperature vs. elevation profile; and
- Solar zenith angle as a function of time.

2. Numerical Integration

The numerical integration module is the heart of REM. This routine accepts as input derivatives calculated by the kinetics and meteorological modules and computes pollutant concentrations and the parcel position forward in simulated time. The kinetics module supplies the derivative of each of the photochemical pollutants computed as a function of time. The meteorological module provides wind velocity outputs as the time derivatives of the position vectors.

The economic use of REM is dependent upon the numerical integration routine. By attaining larger step sizes, the program will execute faster, use less computer time, and be less expensive to operate.

REM utilizes the Adams method of integrating ordinary differential equations of the Gear numerical integration package.[1] A sensitivity analysis has been conducted on the Adams routine in REM. As a result of this examination, it was found that the Adams method executes most economically with the maximum step size at 0.1 minutes and the error limit at .05 in pollutant concentration units.

3. Chemical Kinetics

The chemical kinetics module has operated on reaction mechanisms containing 13-41 reactions and is based on a set of stoichiometrically valid elementary reactions. The current version contains a 32-reaction mechanism that preserves the flexibility of chemical detail necessary for adequate simulation of both primary and secondary contaminants. The set of elementary reactions, rate constants and chemical species is easily modified and expanded as required.

---

[1] C. W. Gear, DIFSUB for Solution of Ordinary Differential Equations, Communications of the ACM, Volume 14, Number 3, March 1971.

This routine calculates the elementary reaction rates and the derivatives of each of the accumulating chemical species as they change with time. It calls the meteorological, ultraviolet and emissions modules into operation, as necessary. The kinetics program adds the perturbations from the traffic and area sources to the derivatives computed for the chemistry for input into the numerical integration routine.

4. Meteorology

This module consists of a series of related routines that employ wind speed and velocity, temperature, relative humidity, elevation, and radiosonde data to calculate the meteorological values, mixing depth and rates of change in the wind at the pollutant column position.

a. Spatial Interpolation

Wind speed and direction, temperature, and relative humidity undergo both spatial and temporal interpolations from numerous meteorological stations to the trajectory location of the air parcel. The spatial interpolation is inversely proportional to the square of the distance from station to parcel. This procedure has two advantages over simply using a ratio inversely proportional to the distance involved. Firstly, it ensures that the meteorological values assigned to the trajectory position are more closely in keeping with the data at the nearest stations; and secondly, it permits the computer program to execute faster by eliminating the necessity of computing square roots.

b. Temporal Interpolation

The temporal interpolation is linear. The meteorological items for the current hour and the next hour are utilized in this process. The portion of each item contributing to the result is directly proportional to the number of minutes in the hour that have passed. For example, at 10:15 A.M. one-quarter of the value for hour 10 would be added to three-quarters of the value for hour 11.

c. Mixing Depth

The model calculates mixing depth on the basis of a temperature versus height profile derived from temperature soundings at various altitudes aloft recorded by radiosonde measurement or aircraft. The mixing height is taken as a function of temperature at the ground and the most recent vertical temperature soundings. The mixing depth is then obtained by subtracting ground elevation at the location of interest. The ground temperature is interpolated at the trajectory point from meteorological data at each station. In this technique the temperature versus height profile is assumed fixed during the day unless more frequent soundings are provided. The mixing depth changes with variations in ground temperature and elevation.

d. Trajectory Derivatives

The rates of change of the wind components at the air parcel position are utilized by the numerical integration routine to calculate the next trajectory position. Two differential equations are reserved for the trajectory calculation. They employ these derivatives in the same manner in which the integration of the differential equations for the chemistry occurs.

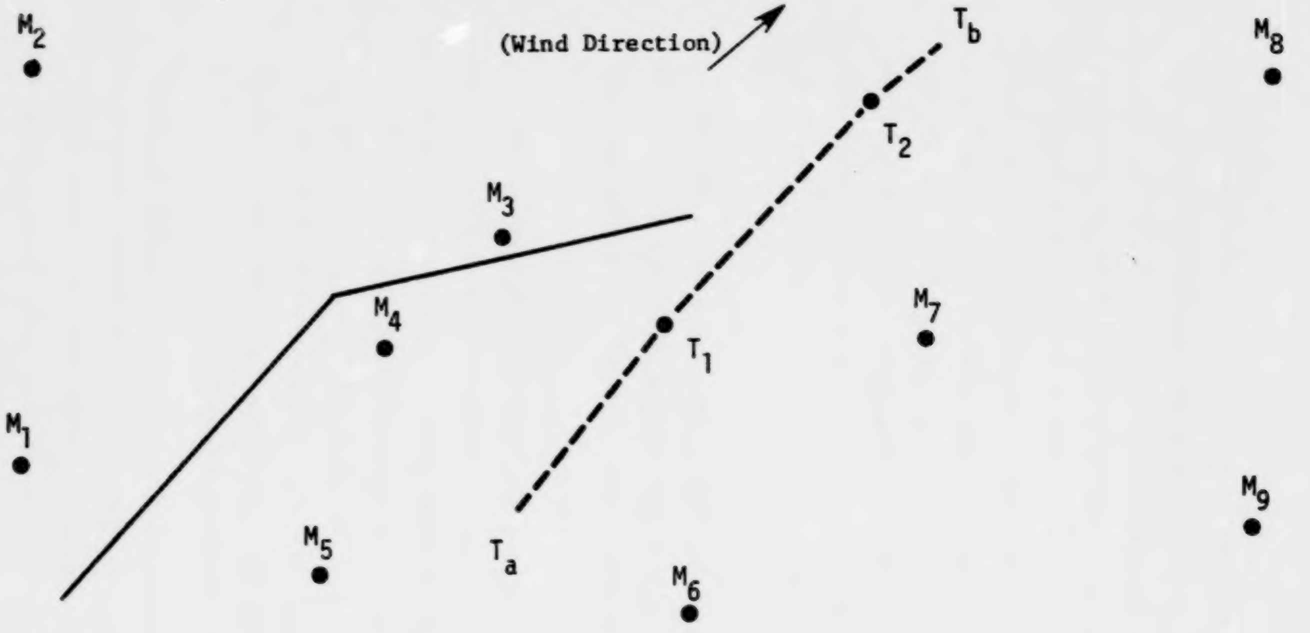
5. Barrier Check

A "barrier" is an imaginary line or set of connected line segments superimposed on the region of interest with the coordinate system for that area. Its purpose is to represent a topographical feature such as a mountain range which may serve to separate sections of an air quality region. The mountain range may tend to influence differing climatological characteristics and wind regimes. For example, on a given day in the Los Angeles Basin, the meteorological characteristics of the Westwood area are likely to differ from those in Van Nuys due, in part, to the intervention of the Santa Monica Mountains. Experience in the Los Angeles area has shown that significant temperature and wind regime differences between the San Fernando Valley and the central Basin tend to occur on any given day.

REM contains two such barriers. One bisects the Santa Monica Mountains and separates the San Fernando Valley from the main section of Los Angeles. The other barrier passes through the Puente and San Jose Hills at the east side of the Basin.

The main function of the barrier routine is to determine the "permissible" meteorological stations. Permissible stations are simply stations which are located in the same general section of the Basin as the trajectory point of interest, as defined by the barriers. That is, both the trajectory point and all stations to be used in the calculation of the trajectory path and the interpolated meteorological values at any trajectory point are located on the same side of each barrier. This is graphically shown in Figure II.4.

The barrier check is intended to ensure that a station which is very close in distance to a trajectory point of interest, but separated from the trajectory point by a mountain range does not exert any influence on the calculation of the trajectory path, temperature, and relative humidity at the trajectory point.



Wind direction

Line T_a - T_b is the trajectory path

T_1 - T_a trajectory point of interest

T_2 - T_a downwind trajectory point along the same trajectory

M_i meteorological stations

P_1 Permissible meteorological stations for T_1 (M_4, M_5, M_6, M_7, M_8, M_9)

P_2 Permissible meteorological stations for T_2 (M_2, M_3, M_5, M_6, M_7, M_8, M_9)

Figure II.4 Demonstration of Barrier Check Technique

6. Ultraviolet Module

This module calculates a diurnal ultraviolet irradiance function based on measurement of sky cover, latitude and local calendar time. The irradiance determines the specific ultraviolet absorption rate of NO_2, which is used in the kinetics module.

7. Source Emissions

This routine computes emissions of NO, CO, reactive hydrocarbons and less reactive hydrocarbons for freeway and street traffic, and calculates emissions from area sources of NO, reactive hydrocarbons, and less reactive hydrocarbons.

The inputs to this program for vehicular sources include two diurnal traffic curves (see Figures II.5 and II.6),[2] emission factors for reactive hydrocarbons, less reactive hydrocarbons, CO and NO in grams per vehicle mile, and distributions of daily vehicle traffic on streets and freeways given in a system of 650 4-square mile grids that cover the Los Angeles Basin (see Figures II.7 and II.8).[2] The emissions of the above pollutants are computed as a function of time by applying their respective emission factors to the traffic levels at the air parcel location qualified by the daily traffic usage curve.

Emissions from area sources are also calculated as a function of time. A constant diurnal usage curve is applied to grid system distributions of hourly pollutant emissions of NO,[3] reactive hydrocarbons, and less reactive hydrocarbons (see Figures II.9, II.10 and II.11).[2]

---

[2] Appendix A, Development of a Simulation Model for Estimating Ground Level Concentrations of Photochemical Pollutants by P. J. W. Roberts, P. M. Roth and C. L. Nelson; Report 71SAI-6, March 1971, prepared by Systems Applications, Inc.

[3] Oxides of nitrogen taken as NO

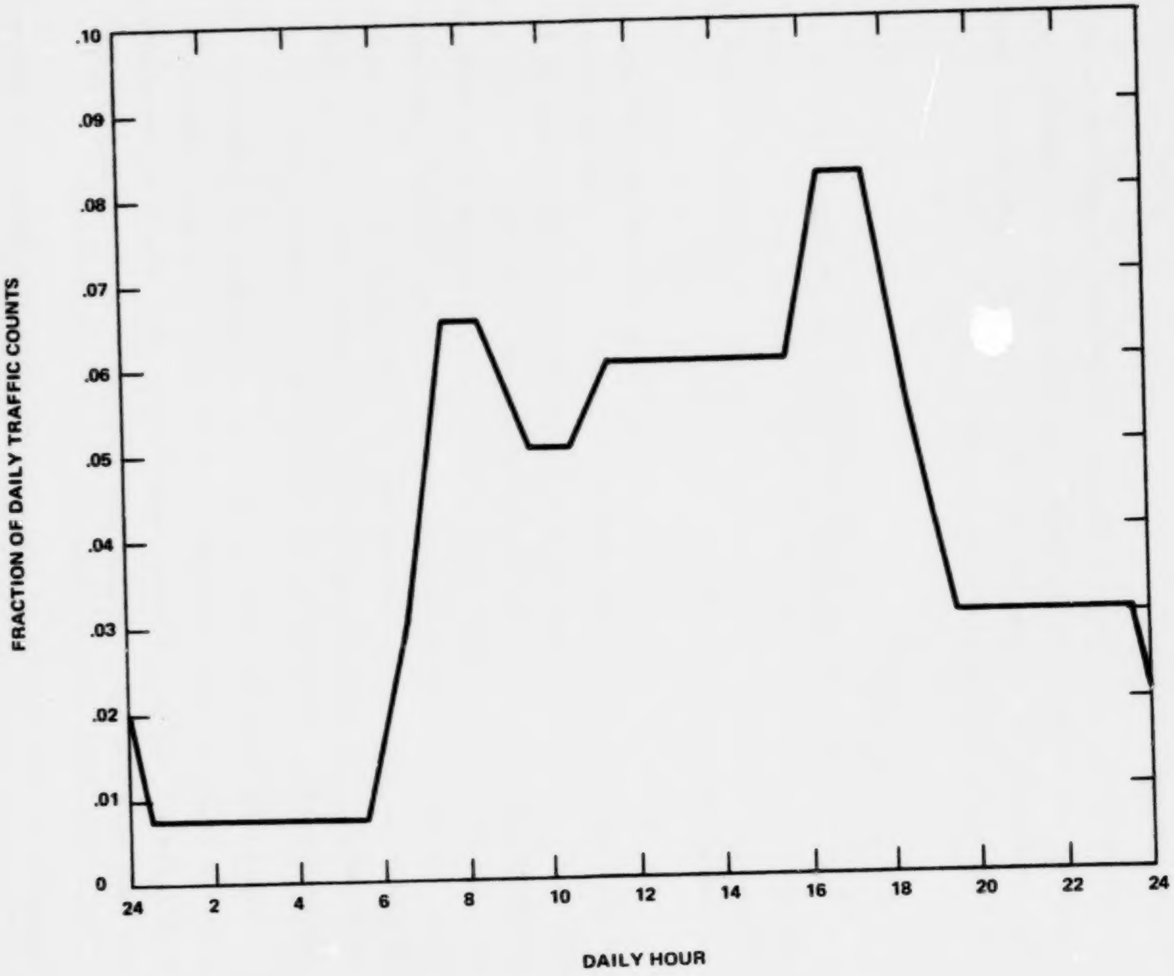


Figure II.5. Temporal Distribution of Daily Street Traffic (Interpreted from Data in Reference 2, pg. II.13)

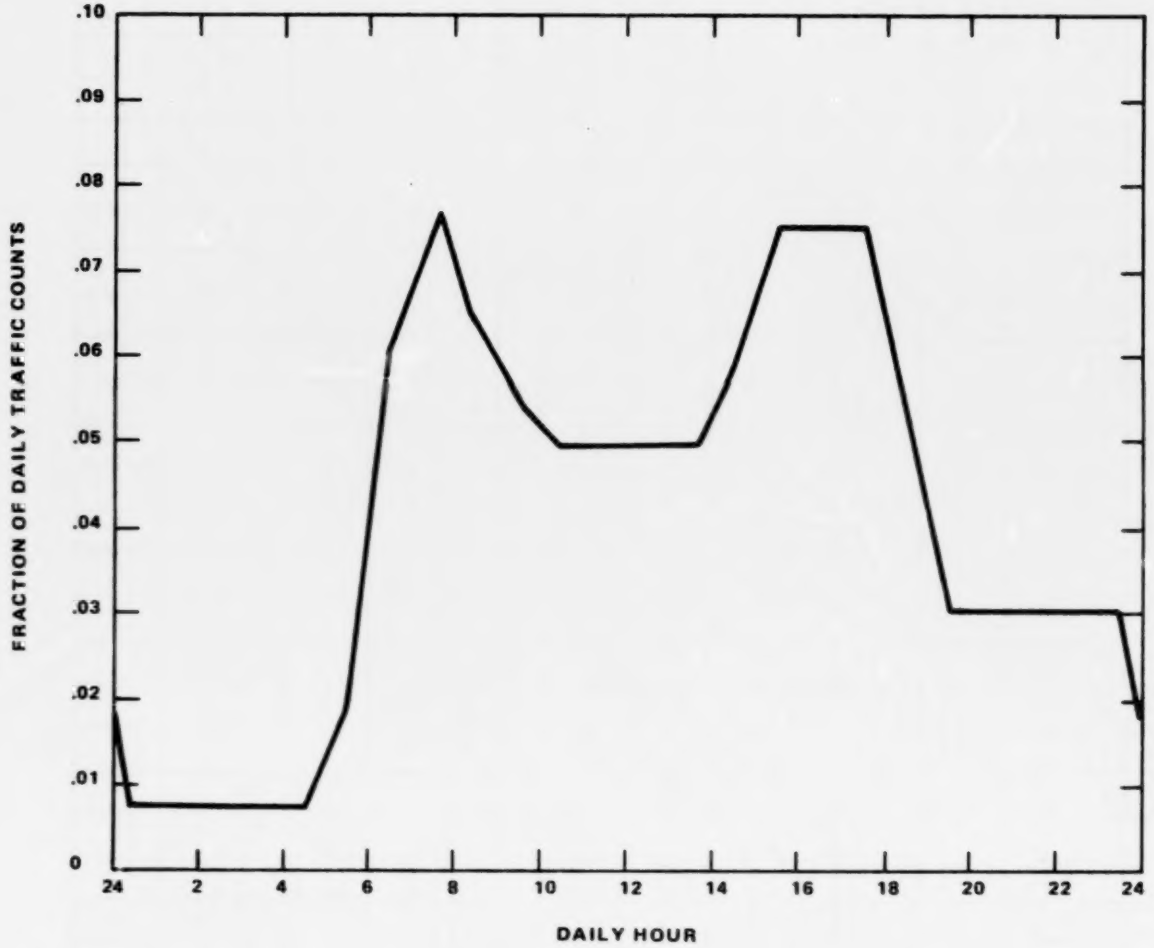
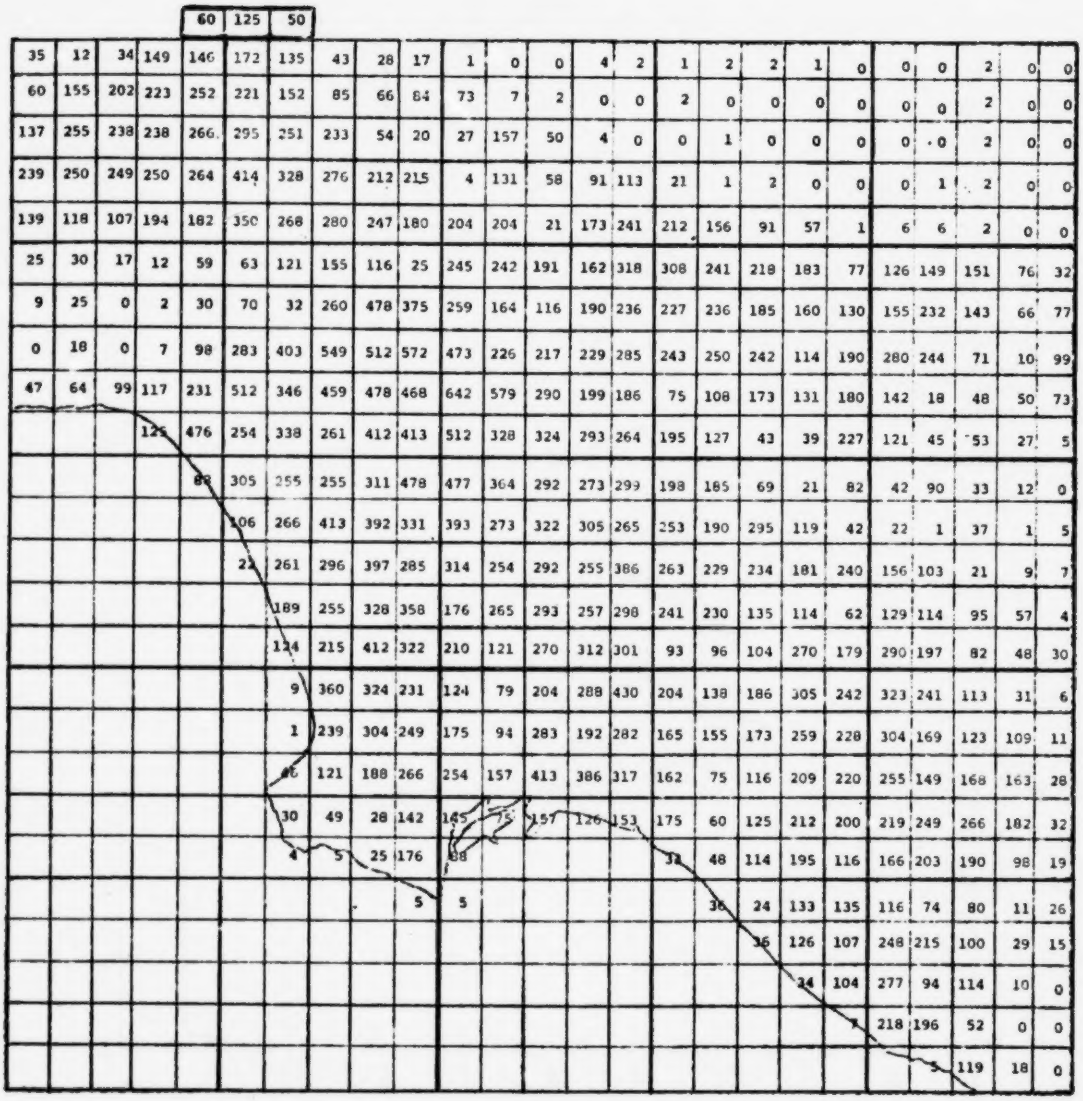


Figure II.6. Temporal Distribution of Daily Freeway Traffic (Interpreted from Data in Reference 2, pg. II.13)



				60	125	50																		
35	12	34	149	146	172	135	43	28	17	1	0	0	4	2	1	2	2	1	0	0	0	2	0	0
60	155	202	223	252	221	152	85	66	84	73	7	2	0	0	2	0	0	0	0	0	0	2	0	0
137	255	238	238	266	295	251	233	54	20	27	157	50	4	0	0	1	0	0	0	0	0	2	0	0
239	250	249	250	264	414	328	276	212	215	4	131	58	91	113	21	1	2	0	0	0	1	2	0	0
139	118	107	194	182	350	268	280	247	180	204	204	21	173	241	212	156	91	57	1	6	6	2	0	0
25	30	17	12	59	63	121	155	116	25	245	242	191	162	318	308	241	218	183	77	126	149	151	76	32
9	25	0	2	30	70	32	260	478	375	259	164	116	190	236	227	236	185	160	130	155	232	143	66	77
0	18	0	7	98	283	403	549	512	572	473	226	217	229	285	243	250	242	114	190	280	244	71	10	99
47	64	99	117	231	512	346	459	478	468	642	579	290	199	186	75	108	173	131	180	142	18	48	50	73
			125	476	254	338	261	412	413	512	328	324	293	264	195	127	43	39	227	121	45	53	27	5
				88	305	255	255	311	478	477	364	292	273	299	198	185	69	21	82	42	90	33	12	0
					106	266	413	392	331	393	273	322	305	265	253	190	295	119	42	22	1	37	1	5
					22	261	296	397	285	314	254	292	255	386	263	229	234	181	240	156	103	21	9	7
						189	255	328	358	176	265	293	257	298	241	230	135	114	62	129	114	95	57	4
						124	215	412	322	210	121	270	312	301	93	96	104	270	179	290	197	82	48	30
						9	360	324	231	124	79	204	288	430	204	138	186	305	242	323	241	113	31	6
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						46	121	188	266	254	157	413	386	317	162	75	116	209	220	255	149	168	163	28
						30	49	28	142	145	75	157	126	153	175	60	125	212	200	219	249	266	182	32
						4	5	25	176	88					32	48	114	195	116	166	203	190	98	19
									5	5						36	24	133	135	116	74	80	11	26
																	36	126	107	248	215	100	29	15
																		34	104	277	94	114	10	0
																			7	218	196	52	0	0
																					5	119	18	0

Figure II.7. Distribution of Street Traffic by Grid Area (thousands of vehicle miles per day) [From Reference 2, pg. II.13]

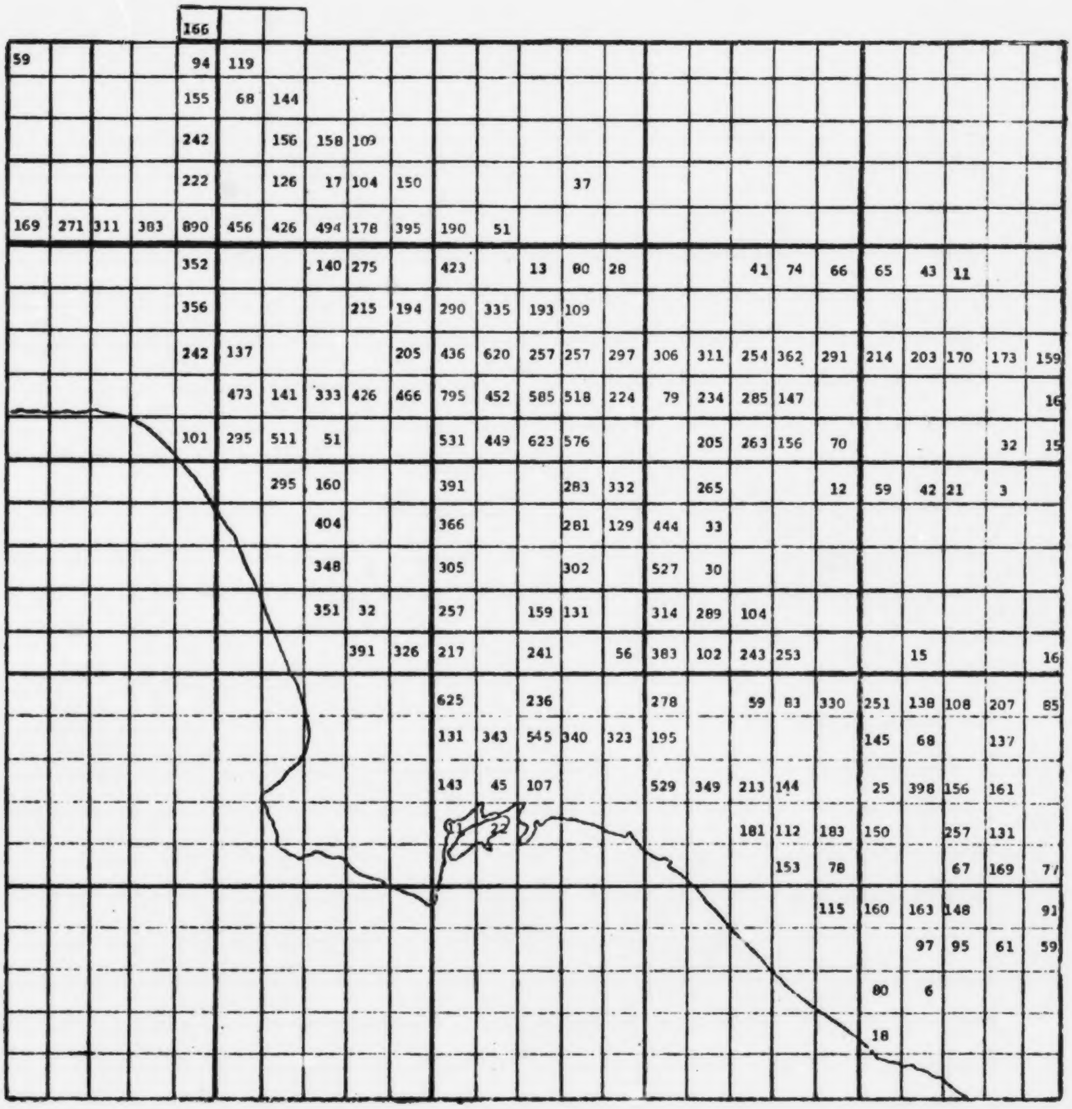
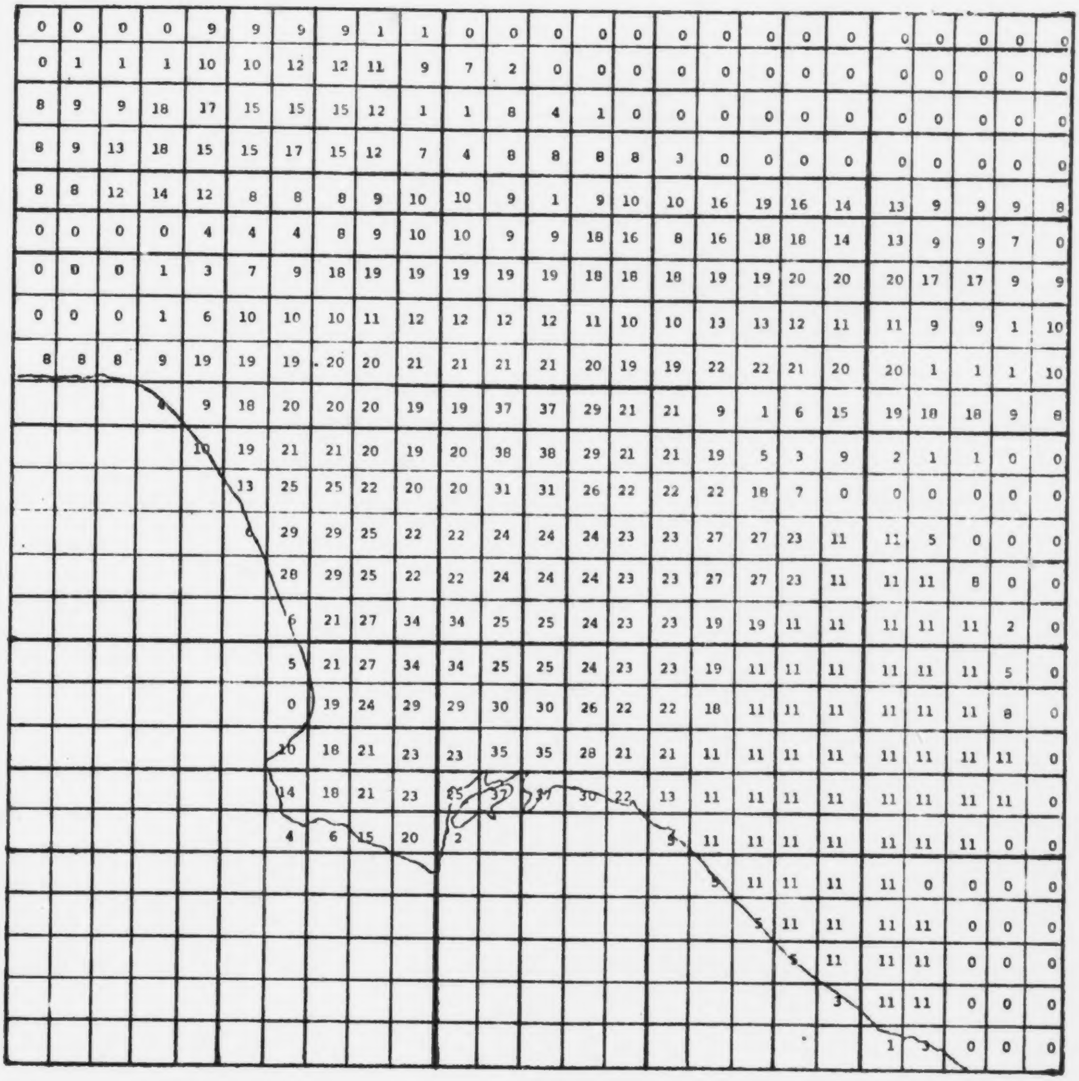
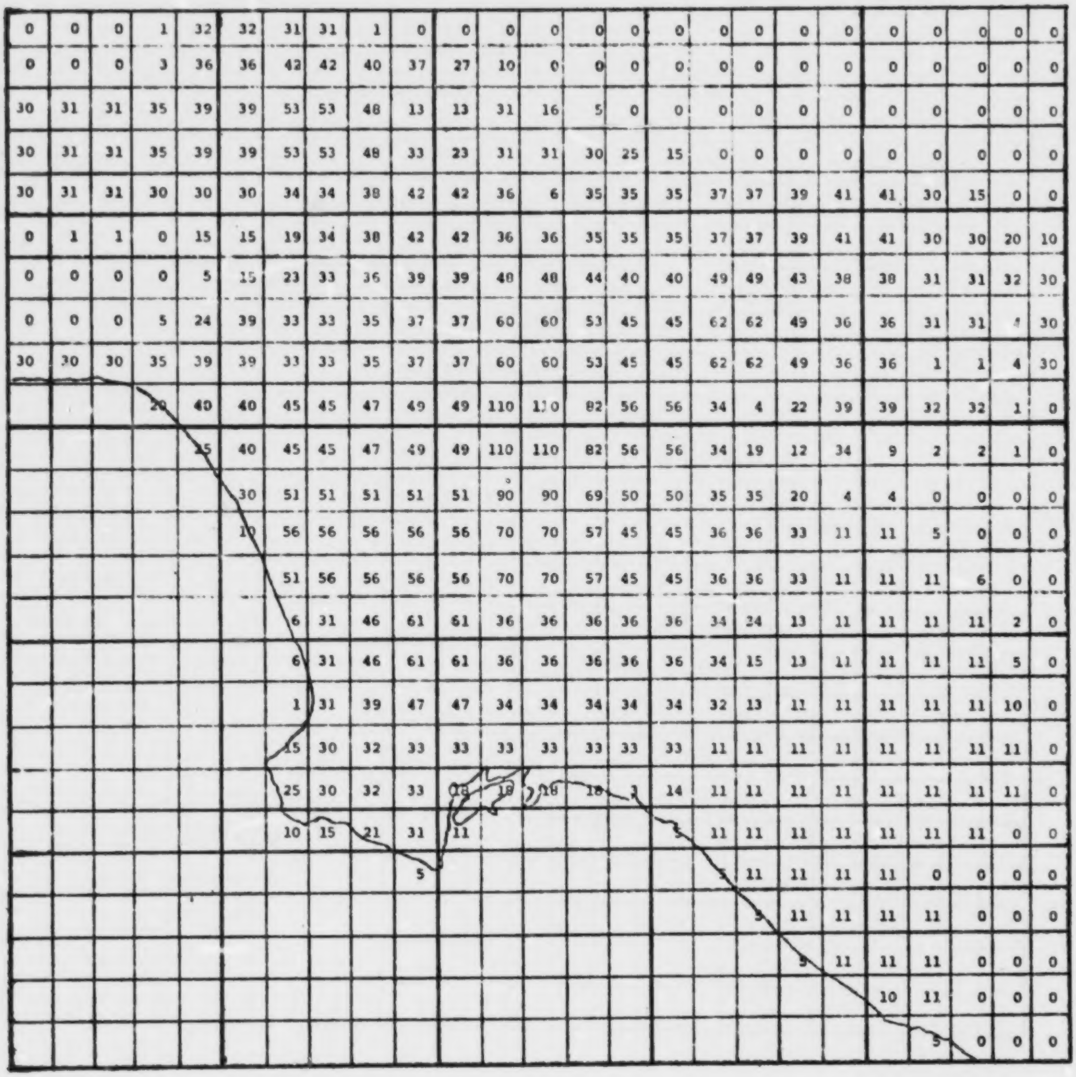


Figure II.8. Distribution of Freeway Traffic by Grid Area (thousands of vehicle miles per day) [From Reference 2, pg. II.13]



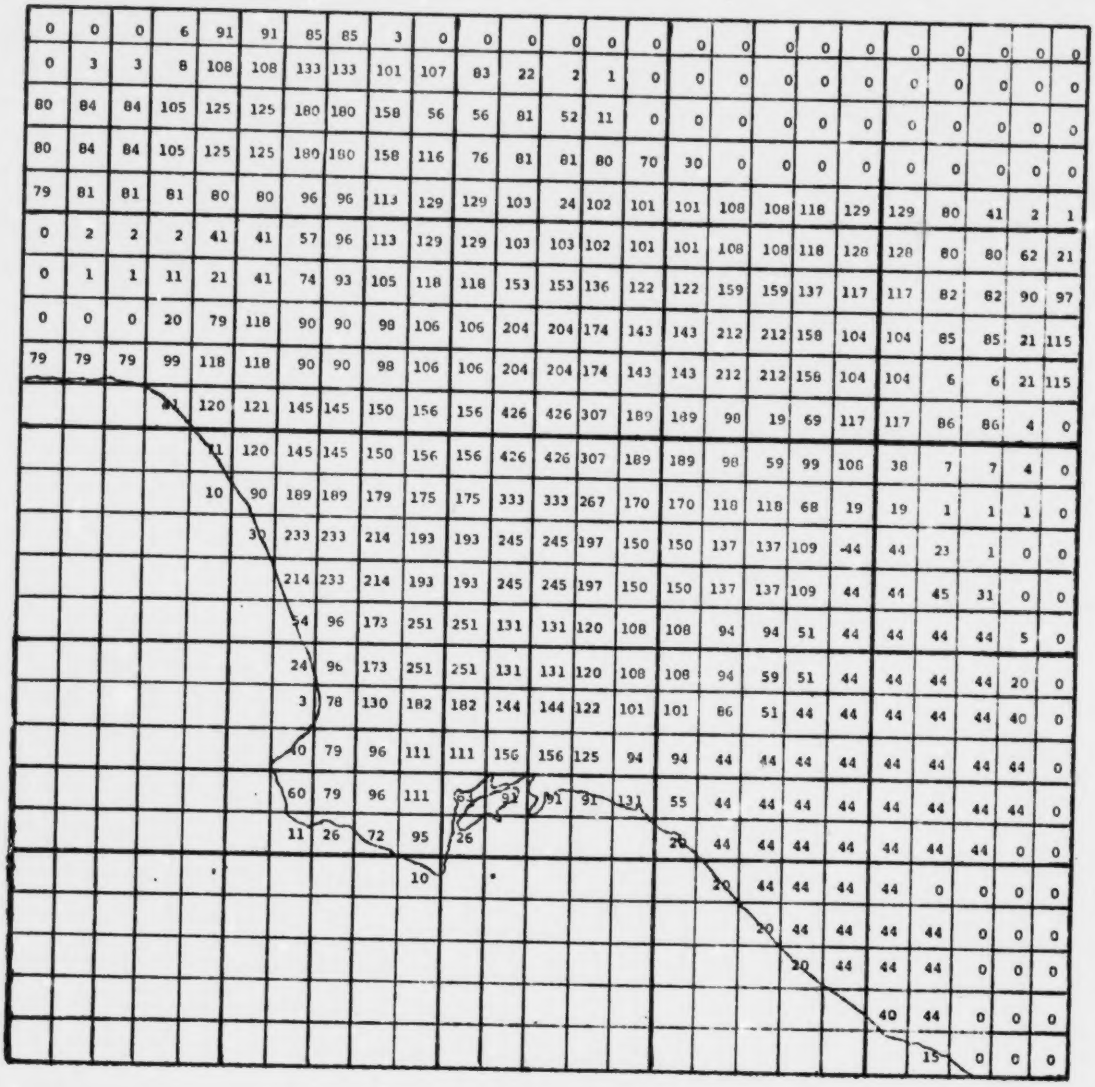
0	0	0	0	9	9	9	9	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	1	10	10	12	12	11	9	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0
8	9	9	18	17	15	15	15	12	1	1	8	4	1	0	0	0	0	0	0	0	0	0	0	0
8	9	13	18	15	15	17	15	12	7	4	8	8	8	8	3	0	0	0	0	0	0	0	0	0
8	8	12	14	12	8	8	8	9	10	10	9	1	9	10	10	16	19	16	14	13	9	9	9	8
0	0	0	0	4	4	4	8	9	10	10	9	9	18	16	8	16	18	18	14	13	9	9	7	0
0	0	0	1	3	7	9	18	19	19	19	19	19	18	18	18	19	19	20	20	20	17	17	9	9
0	0	0	1	6	10	10	10	11	12	12	12	12	11	10	10	13	13	12	11	11	9	9	1	10
8	8	8	9	19	19	19	20	20	21	21	21	21	20	19	19	22	22	21	20	20	1	1	1	10
			4	9	18	20	20	20	19	19	37	37	29	21	21	9	1	6	15	19	18	18	9	8
				10	19	21	21	20	19	20	38	38	29	21	21	19	5	3	9	2	1	1	0	0
					13	25	25	22	20	20	31	31	26	22	22	22	18	7	0	0	0	0	0	0
					6	29	29	25	22	22	24	24	24	23	23	27	27	23	11	11	5	0	0	0
						28	29	25	22	22	24	24	24	23	23	27	27	23	11	11	11	8	0	0
						6	21	27	34	34	25	25	24	23	23	19	19	11	11	11	11	11	2	0
						5	21	27	34	34	25	25	24	23	23	19	11	11	11	11	11	11	5	0
						0	19	24	29	29	30	30	26	22	22	18	11	11	11	11	11	11	8	0
						10	18	21	23	23	35	35	28	21	21	11	11	11	11	11	11	11	11	0
						14	18	21	23	25	37	37	30	22	13	11	11	11	11	11	11	11	11	0
						4	6	15	20	2					5	11	11	11	11	11	11	11	0	0
																5	11	11	11	11	0	0	0	0
																	5	11	11	11	11	0	0	0
																		5	11	11	11	0	0	0
																			3	11	11	0	0	0
																				1	3	0	0	0

Figure II.9. Distribution of Reactive Hydrocarbon Emissions (average kilograms/hour) by Grid Area
[From Reference 2, pg. II.13]



0	0	0	1	32	32	31	31	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	3	36	36	42	42	40	37	27	10	0	0	0	0	0	0	0	0	0	0	0	0	0
30	31	31	35	39	39	53	53	48	13	13	31	16	5	0	0	0	0	0	0	0	0	0	0	0
30	31	31	35	39	39	53	53	48	33	23	31	31	30	25	15	0	0	0	0	0	0	0	0	0
30	31	31	30	30	30	34	34	38	42	42	36	6	35	35	35	37	37	39	41	41	30	15	0	0
0	1	1	0	15	15	19	34	38	42	42	36	36	35	35	35	37	37	39	41	41	30	30	20	10
0	0	0	0	5	15	23	33	36	39	39	48	48	44	40	40	49	49	43	38	38	31	31	32	30
0	0	0	5	24	39	33	33	35	37	37	60	60	53	45	45	62	62	49	36	36	31	31	4	30
30	30	30	35	39	39	33	33	35	37	37	60	60	53	45	45	62	62	49	36	36	1	1	4	30
			20	40	40	45	45	47	49	49	110	110	82	56	56	34	4	22	39	39	32	32	1	0
				25	40	45	45	47	49	49	110	110	82	56	56	34	19	12	34	9	2	2	1	0
					30	51	51	51	51	51	90	90	69	50	50	35	35	20	4	4	0	0	0	0
					10	56	56	56	56	56	70	70	57	45	45	36	36	33	11	11	5	0	0	0
						51	56	56	56	56	70	70	57	45	45	36	36	33	11	11	11	6	0	0
						6	31	46	61	61	36	36	36	36	36	34	24	13	11	11	11	11	2	0
						6	31	46	61	61	36	36	36	36	36	34	15	13	11	11	11	11	5	0
						1	31	39	47	47	34	34	34	34	34	32	13	11	11	11	11	11	10	0
						15	30	32	33	33	33	33	33	33	33	11	11	11	11	11	11	11	11	0
						25	30	32	33	18	18	18	18	3	14	11	11	11	11	11	11	11	11	0
						10	15	21	31	11					5	11	11	11	11	11	11	11	0	0
									5							5	11	11	11	11	0	0	0	0
																	5	11	11	11	11	0	0	0
																		5	11	11	11	0	0	0
																				10	11	0	0	0
																					5	0	0	0

Figure II.10. Distribution of Oxides of Nitrogen Emissions Taken as Nitric Oxide (average kilograms/hour) by Grid Area [From Reference 2, pg. II.13]



0	0	0	6	91	91	85	85	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	3	8	108	108	133	133	101	107	83	22	2	1	0	0	0	0	0	0	0	0	0	0	0
80	84	84	105	125	125	180	180	158	56	56	81	52	11	0	0	0	0	0	0	0	0	0	0	0
80	84	84	105	125	125	180	180	158	116	76	81	81	80	70	30	0	0	0	0	0	0	0	0	0
79	81	81	81	80	80	96	96	113	129	129	103	24	102	101	101	108	108	118	129	129	80	41	2	1
0	2	2	2	41	41	57	96	113	129	129	103	103	102	101	101	108	108	118	128	128	80	80	62	21
0	1	1	11	21	41	74	93	105	118	118	153	153	136	122	122	159	159	137	117	117	82	82	90	97
0	0	0	20	79	118	90	90	98	106	106	204	204	174	143	143	212	212	158	104	104	85	85	21	115
79	79	79	99	118	118	90	90	98	106	106	204	204	174	143	143	212	212	158	104	104	6	6	21	115
			41	120	121	145	145	150	156	156	426	426	307	189	189	98	19	69	117	117	86	86	4	0
				11	120	145	145	150	156	156	426	426	307	189	189	98	59	99	108	38	7	7	4	0
				10	90	189	189	179	175	175	333	333	267	170	170	118	118	68	19	19	1	1	1	0
					30	233	233	214	193	193	245	245	197	150	150	137	137	109	44	44	23	1	0	0
						214	233	214	193	193	245	245	197	150	150	137	137	109	44	44	45	31	0	0
						54	96	173	251	251	131	131	120	108	108	94	94	51	44	44	44	44	5	0
						24	96	173	251	251	131	131	120	108	108	94	59	51	44	44	44	44	20	0
						3	78	130	182	182	144	144	122	101	101	86	51	44	44	44	44	44	40	0
						40	79	96	111	111	156	156	125	94	94	44	44	44	44	44	44	44	44	0
						60	79	96	111	63	91	91	91	131	55	44	44	44	44	44	44	44	44	0
						11	26	72	95	26					20	44	44	44	44	44	44	44	0	0
									10							20	44	44	44	44	0	0	0	0
																	20	44	44	44	44	0	0	0
																		20	44	44	44	0	0	0
																				40	44	0	0	0
																					15	0	0	0

Figure II.11. Distribution of Less Reactive Hydrocarbon Emissions (average kilograms/hour) by Grid Area [From Reference 2, pg. II.13]

```
 TIME= 0.38019937D 03 MINUTES     STEP= 66     POSITION= 58.4039, 40.3573      STEP SIZE= 0.10000000D 00      PAGE  13

                          EXPECTED RATE OF CHANGE OF CONCENTRATIONS DUE TO EMISSIONS FROM REGIONAL SOURCES
                                       PPHM/MIN                                             GRAM-MOLES/MIN
                        PROPYLENE      NO          CO          DUMHC          PROPYLENE     NO          CO          DUMHC
  STREET TRAFFIC       0.3660D-02  0.1025D-01  0.2196D 00  0.4918D-01       0.5274E-06  0.1477E-05  0.3165E-04  0.7089E-05
  FREEWAY TRAFFIC      0.1446D-02  0.4049D-02  0.8677D-01  0.1944D-01       0.2084E-06  0.5836E-06  0.1251E-04  0.2801E-05
  AREA SOURCES         0.1752D-02  0.1547D-02              0.7252D-01       0.2525E-06  0.2230E-06              0.1045E-04


                RELATIVE                   MIXING      MIXING
  TEMPERATURE   HUMIDITY   ELEVATION       HEIGHT       DEPTH
    (CENT.)                 (METERS)      (METERS)    (METERS)

     27.2137     0.2871     181.3918      757.9106    576.5190

     COMPOUND     CONC PPHM      CHANGE, PPHM/MIN
    1 NO2         0.10570770 02  -0.15016660-01
    2 NO          0.74260920 00  -0.28831680-02
    3 O3          0.13083660 02   0.27850620-01
    4 C3H6        0.58290440 00  -0.48061620-02
    5 HNO3        0.29533170 01   0.11190490-01
    6 CH3CHO      0.71383390 01  -0.55822400-04
    7 HCHO        0.34705030 01  -0.70338840-02
    8 CO (PPM)    0.46419780 01  -0.38063320-02
    9 CH3ONO2     0.39845050 00  -0.15815400-03
   10 C2H3NO5     0.55473800 00   0.41342320-03
   11 FIXED O2    0.0             0.0
   12 DUMHC       0.11756080 03  -0.33399040-01
   13             0.0
   14 H           0.38162460-07
   15 OH          0.12446960-04
   16 HO2         0.52582540-02
   17 CH3         0.68931480-08
   18 CH3O        0.40259910-04
   19 CH3O2       0.38551340-02
   20 C2H3O       0.14202760-06
   21 C2H3O2      0.79538800-03
   22 C2H4O2      0.10959920-05
   23 O           0.28038470-05
   24 NO3         0.11161670-05
   25 C2H3O3      0.57995750-03
```

Figure II.12. Sample REM Output

8. Output Routine

This program prints output data at various times along the trajectory route. The user may specify the times at which the printouts are to occur and the routine checks to see if a requested output time has been reached. A sample output is shown in Figure II.12. The primary data categories printed include:

- Time of output and trajectory position;
- Step size;
- Rate of change of concentrations from source routine in pphm/minute and in gram-moles/minute;
- Meteorological values at the trajectory point including mixing depth;
- Pollutant concentrations;
- Rates of change of accumulating (primary) pollutants; and
- Rates of the elementary reactions.

9. Plotting Routine

At the end of the simulation run, this program outputs three digital plots containing the history of each accumulating pollutant represented in time vs. concentration curves. An example of this output is shown in Figure II.13.

10. Reverse Trajectory Program

The reverse trajectory program calculates wind trajectories and interpolates initial concentration values for use by the simulation model. Its primary inputs consist of hourly average wind data monitored at a network of meteorological stations, and hourly average pollutant data recorded at a group of pollutant monitoring stations. The coordinate positions of these stations are also required.

In addition, the user must specify a coordinate position and the length of time for which the simulated trajectory is to be calculated. The program then considers the given coordinate position to be the

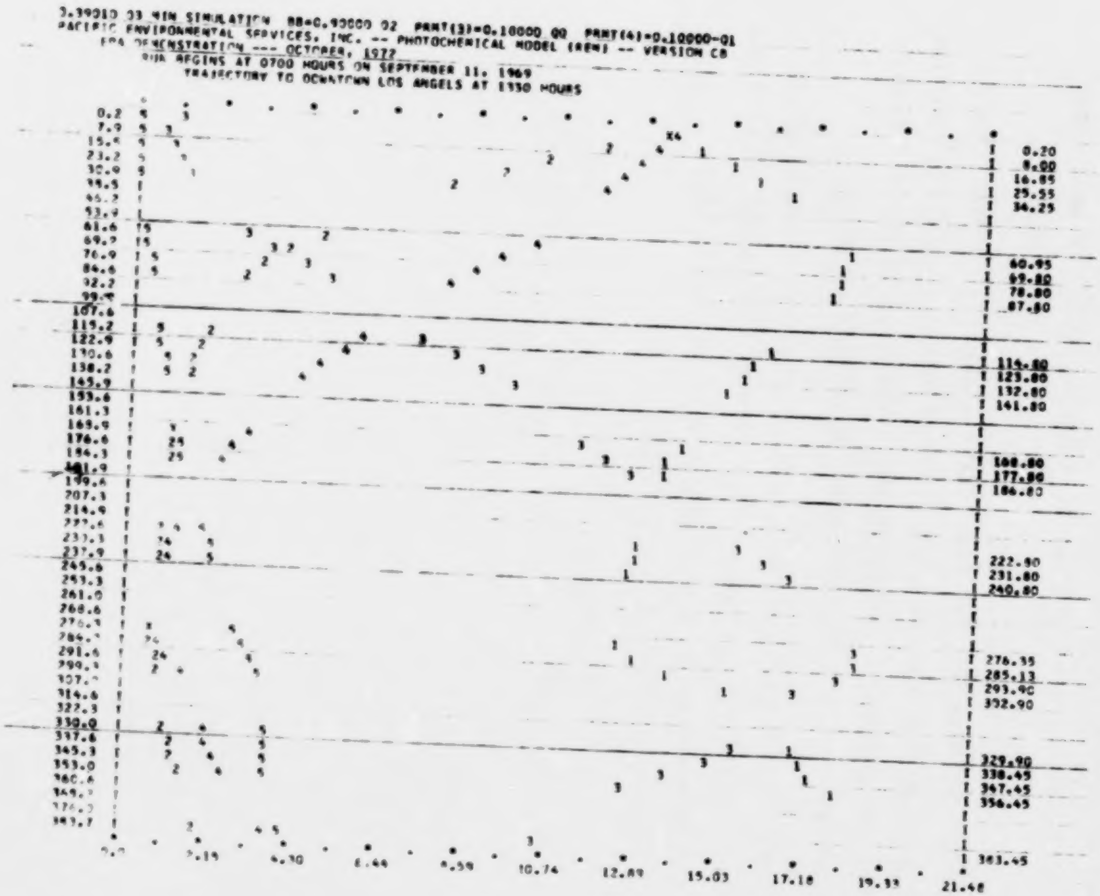


Figure II.13. Digital Plot of Primary Pollutant Time vs. Concentration Histories

Vertical axis represents time in minutes; horizontal axis depicts pollutant concentrations in pphm. The species plotted are as follows: 1 - NO_2, 2 - NO, 3 - O_3, 4 - C_3H_6, and 5 - HNO_3.

terminus of the trajectory, and computes consecutive points along the trajectory in a direction opposite to that of the wind. At the conclusion of the trajectory (the determination of the starting point), an interpolation routine calculates initial concentrations for nitrogen dioxide, nitric oxide, ozone and carbon monoxide from the pollutant data.

Although its primary use has been for calculating reverse trajectories, the program may also be used for computing forward trajectories. In this case, the pollutant interpolation routine would yield concentration values which could be considered as validation points.

Theoretically, the program could operate with one meteorological and one pollutant station. However, the greater the number of stations utilized, the more realistic and accurate will be the results.

Section III

Mathematical Description of the Reactive Pollution Simulation Model (REM)

A. METEOROLOGICAL MODULE

1. Introduction

The meteorological module calculates weather parameters at the air parcel location after considering the effect of natural barriers such as mountain ranges. This routine also determines the mixing depth and the rates of change of the wind components at this point.

2. Derivations

a. The Barrier Routine and Definition of Permissible Stations

A barrier is a set of adjoining line segments utilized by the REM to represent a natural obstacle such as a mountain range. The barrier program's function is to determine the set of "permissible" meteorological stations employable by the meteorological routine for interpolating wind speed and direction, temperature, relative humidity and ground elevation. A station is permissible if and only if it is located on the same side of a barrier as is the air parcel. This is expressed mathematically below.

Each barrier is defined by an integer N_B, which is one greater than the number of barrier sides, and a sequence of points (x_i, y_i), $i=1, 2, \ldots, N_B$, with each consecutive pair of points defining a side of the barrier. Let (x_o, y_o) and (x_s, y_s) be, respectively, the coordinate of the trajectory point and a given station. Let $m = (y_s-y_o)/(x_s-x_o)$, $b = y_o-mx_o$ be the slope and y the intercept of the line joining the trajectory point to the station. For each $i = 1, 2, \ldots, N_B-1$ let

$$m_i = (y_{i+1}-y_i)/(x_{i+1}-x_i)$$

$$b_i = y_i-m_i x_i$$

$$\lambda_i = \frac{y_s-m_i x_i-b_i}{m_i(x_o-x_s)-(y_o-y_s)}$$

$$\mu_i = \frac{y_{i+1}-mx_{i+1}-b}{m(x_i-x_{i+1})-(y_i-y_{i+1})}$$

A station located at (x_s, y_s) is said to be permissible if, and only if, for each $i=1, 2, \ldots, N_B-1$ either

$$\lambda_i \geq 0,\ \lambda_i \geq 1,\ \mu_i \leq 0 \text{ or } \mu_i \geq 1.$$

b. Interpolation of Meteorological Variables

A spatial interpolation is performed automatically for the data values from two successive hours. This is followed by a linear temporal interpolation for the two spatially interpolated values for each of four meteorological variables. The spatial interpolation is given as follows: Let (x_j, y_j) be the coordinates of each permissible station $(j=1,2,\ldots N_p)$. Let $d_1,d_2,d_3,\ldots,d_{N_p}$ be the distance from these stations to the trajectory point and let $\dot{x}_1,\dot{x}_2,\ldots,\dot{x}_{N_p}$ be, for example, the corresponding set of observed x components of wind velocity. The x component of wind velocity, $\dot{x}_o$, at the trajectory point is estimated according to:

$$\dot{x}_o=\left(\sum_{j=1}^{N_p}\dot{x}_j/d_j^{\,2}\right)/A \tag{III.1}$$

Each of the three remaining trajectory point variables is estimated by the corresponding analogue to equation (III.1).

For example, if the calculation is being conducted for a trajectory point at 0715 hours, then two interpolations are conducted for each of four variables (x and y wind components, temperature, and relative humidity). One interpolation is calculated for 0700 and the other for 0800.

This is followed by a temporal interpolation for each set of spatially interpolated variables given by:

$$x = x_1 + (x_2-x_1)-(t-t_1) \qquad \text{(III.2)}$$

where: x is the interpolated value;

x_1 is the spatially interpolated value at hour 1;

x_2 is the spatially interpolated value at hour 2;

t_1 is the time of hour 1;

t is the time of day where $t \geq t_1$.

In the example above, equation (III.2) would cause 25% of the 0700 value to be added to 75% of the 0800 value.

c. Rates of Change of the Wind Components

The wind component rates of change are easily computed by dividing the hourly interpolations of these variables by 60. These values are then passed to the numerical integration routine where they are utilized in the integration process by the ordinary differential equations reserved for the trajectory calculation.

d. Computation of Mixing Height

The mixing height is computed by passing a straight line of slope -.00986 (the dry adiabatic lapse rate) through the trajectory height-temperature point and determining the abscissa of its intersection with the radiosonde curve. The mixing depth is calculated by subtracting interpolated height-above-sea-level from the mixing height.

Given the interpolated values (z_o,T_o) of height above sea level and temperature at our trajectory point, the module selects the appropriate A.M. or P.M. radiosonde curve depending of the value t_o. Each of these curves is defined by an integer $N_{a.m.}$ or $N_{p.m.}$ and a sequence of points (z_k, T_k) $k=1,2,\ldots N_{a.m.(p.m.)}$. The mixing height, h_m, is computed according to:

$$h_m = \frac{T_o - T_k + m_k z_k - \alpha z_o}{m_k - \alpha}$$

where k is the first integer such that $1 \leq k < N_{a.m.(p.m.)}$, $z_k < h_m < z_{k+1}$, $z_o \leq h_m$, $m_k = (T_{k+1} - T_k)/(z_{k+1} - z_k)$, and $\alpha = -.00986$ °C/meter.

3. Symbol Glossary and Units

t_o [hours] = time of day
$\dot{x}_o$ [meters/minute] = x component of wind velocity
$\dot{y}_o$ [meters/minute] = y component of wind velocity
T_o [degree centigrade (°C)] = temperature
P_o [millibar] = pressure
H_o [dimensionless] = relative humidity
w_o [dimensionless] = cloud cover
z_o [meters] = height-above-sea-level
h_m [meters] = mixing height

B. ULTRAVIOLET IRRADIANCE MODULE

1. Introduction

The basic physical hypotheses underlying this module's computations have been taken almost directly from [1]. Our departure is in the formulation of a total irradiance equation which takes into account albedo and weather effects and which reduces to a standard form (see equation II-29 of [1] when the cloud cover and albedo are both zero. Thus, our final formulation (see equation III.3) will differ from any developed on the basis of equation (II-38) of [1]. The input to the module is the time t_o, the height above sea level of the trajectory point, z_o, the relative humidity at the trajectory point H_o, the corresponding atmospheric pressure p_o, the mixing height, h_m, the weather cover, w_o, and the average concentration of NO_2, $\bar{C}_{NO_2}$, in the column. The module's output is the specific absorption rate of NO_2, k_{NO_2}.

2. Derivations

As a function of the time of day, t_o (Pacific Standard Time), a value of the solar zenith angle θ, is interpolated from a table derived from the equinox curve of Figure 2 in Chapter II of [1]. The air mass, m, is interpolated as a function of θ in Table 2 of [1].

Depending of an input cloud-type parameter, a value of average fraction of radiation transmitted, β, is interpolated in Table 10 of [1]. For each wavelength band of 100Å in a wavelength region of $3000Å \le \lambda \le 4000Å$, the molecular scattering coefficient $(s_{m\lambda})_o$ is selected from Table 3 of [1]. From equation (II-9) of [1], the transmissivity relative to molecular scattering, $T_{m\lambda}$, may be computed from the formula

$$\log_{10} T_{m\lambda} = -(s_{m\lambda})_o \frac{p_o m}{1013.250}$$

where p_o is the interpolated pressure in millibars.

The transmissivity relative to particle scattering, $T_{p\lambda}$, may be computed from the formula (II-11) of [1] (with λ in microns)

$$\log_{10} T_{p\lambda} = -(3.75\text{x}10^{-3}\lambda^{-2}W+3.5\text{x}10^{-2}\lambda^{-.75}d)m$$

where W is the amount of precipitable water vapor in the atmosphere, measured vertically above the trajectory point, computed as in equation (II-2) of [1], in units of centimeters, according to:

$$W = 1.722\text{x}10^{-1}P_W 10^{-(z_o/22,000)}$$

P_W is the partial pressure in millibars of water vapor at the trajectory point. P_W is interpolated from a vapor pressure table in [2], and d is a dimensionless parameter of preset nominal value 1.

The ozone absorption coefficient α_λ [meters^{-1}] is interpolated from Table 5 of [1] and the transmissivity of ozone, $T_{a\lambda}$, as in equation (II-13) of [1], may be computed from

$$\log_{10} T_{a\lambda} = -\alpha_\lambda (O_3) m$$

where (O_3) is a preset parameter of nominal value $2.2\mathrm{x}10^{-3}$ [meters] (of ozone).

The mean solar spectral irradiance $I_{0\lambda}$, is selected from Table 1 of [1] and the direct and sky radiation $I_{d\lambda}$ and $I_{s\lambda}$ are computed from equations (II-15) and (II-16) of [1]:

$$I_{d\lambda} = T_{s\lambda}\, T_{a\lambda}\, I_{0\lambda} \cos\theta$$

$$I_{s\lambda} = g(1-T_{s\lambda}) T_{a\lambda} I_{0\lambda} \cos\theta$$

where $T_{s\lambda} = T_{m\lambda} T_{p\lambda}$ and g is a preset dimensionless parameter of nominal value .5.

Following the development from equations (II-17) through (II-28) of [1] and taking average weather cover and an average albedo effect into account we obtain the formula for the average rate of absorption per unit pollutant column volume for direct and sky radiation over a wavelength band of 100Å centered at wavelength λ, $I_{a\lambda}$:

$$I_{a\lambda} = \frac{\left\{1+a\right\}\left\{I_{d\lambda}(1-w_o)(1-10^{-\alpha_\lambda \bar{C}_{NO_2} h_m \sec\theta}) + \left[\beta w_o I_{d\lambda} + (1-w_o+\beta w_o) I_{s\lambda}\right](1-10^{-2\alpha_\lambda \bar{C}_{NO_2} h_m})\right\}}{h_m} \quad \text{(III.3)}$$

where a is the albedo (preset nominal value of .235), w_o is the weather cover, and $\bar{C}_{NO_2}$ is the average column concentration of NO_2. $\alpha\lambda$ now refers to NO_2.

Finally, the specific absorption rate of NO_2, k_{NO_2} derived from equations (II-31) and (II-32) of [1] is computed as:

$$k_{NO_2} = \frac{1}{7.2} \times 10^{-16}\left(\frac{273+T_o}{p_o\bar{C}_{NO_2}}\right)\sum_{\lambda=3000\mathring{A}}^{4000\mathring{A}} I_{a\lambda}$$

In passing we note that in our formulation equation (III.3) reduces to (II-29) of [1] when a=0 and $w_o=0$ ($\gamma=w_o$), but equation (II-38) does not.

3. Units

All lengths are in meters.

Time is in minutes.

Temperature is in °C.

All pressures are in millibars.

$I_{0\lambda}$ are in photons meters^{-2} $\text{minutes}^{-1}(100\mathring{A})^{-1}$.

$\bar{C}_{NO_2}$ is in pphm.

k_{NO_2} is in minutes^{-1}.

w_o is dimensionless.

β is dimensionless.

4. References

[1] P. A. Leighton, Photochemistry of Air Pollution, Academic Press, New York, 1961.

[2] Handbook of Physics and Chemistry

C. KINETICS MODULE EQUATIONS

1. Introduction

We first characterize an abstract k step $-N_\sigma$ species constant mass, constant volume chamber photochemical mechsnism. As a consequence of this characterization, using standard principles of chemical kinetics, we can write, in compact notation, the differential equations of species concentration for the constant volume, constant mass situation. Next we expand our conceptual framework to the chemical kinetics of the contents of a pollutant column whose motion over a time-varying field of urban emission sources induces variations in average column temperature, colume mass, etc. This is accomplished by adding a series of appropriate first order perturbation terms to the species concentration time derivatives. It is to be emphasized that the number of reactions and number of species characterizing our imbedded kinetic mechanism are limited only by computer storage and computation time considerations. For this reason we are utilizing the IBM 370/155, a high-speed, large storage computer, in conjunction with an auxiliary FORTRAN system whose function is to derive a set of differential equations from a corresponding set of photochemical equations. Thus, we have complete flexibility in reaction number, species number and, more importantly, the photochemical equations themselves.

The inputs to the module are the outputs of the weather, diffusion, and ultraviolet irradiance modules.

2. Derivations

An abstract k-reaction, N_σ-species, constant-volume, constant-mass photochemical mechanism is characterized by (i) a binary valued $k \times N_\sigma$ matrix B whose (i,j) element, b_{ij}, is 1 if, and 0 unless, the jth species appears as a reactant in the i^{th} (elementary) step; (ii) an integer valued $k \times N_\sigma$ species conservation matrix, P, whose (i,j) element, P_{ij}, is the number of molecules of species j produced ($p_{ij} \geq 0$) or consumed ($p_{ij} < 0$) in the i^{th} step; (iii) a K-element vector F of reaction rate factors k_j, j=1, 2,...K; and (iv) a N_σ-element vector, C_o, of initial concentrations, $C_\ell(0)$, $\ell=1, 2, \ldots, N_\sigma$. From the above definitions and elementary considerations of chemical kinetics, we may formulate the following set of differential equations:

$$\dot{C}_i(t) = \sum_{j=1}^{k} p_{ji} k_j \left(\prod_{\{\ell : b_{j\ell}=1\}}^{N_\sigma} C_\ell(t) \right), \qquad \text{(III.4)}$$

$$C_i(0) = C_{io}$$

$$(i = 1,2,\ldots,N_\sigma)$$

or, in matrix-vector form:

$$\dot{C}(t) = P^T R(t)$$

$$C(0) = C_o,$$

where

$$\dot{C}(t) = \begin{bmatrix} \dot{C}_1(t) \\ \dot{C}_2(t) \\ \dot{C}_3(t) \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \dot{C}_{N_\sigma}(t) \end{bmatrix},$$

$$R(t) = \begin{bmatrix} k_1 \prod_{\{\ell : b_{1\ell}=1\}} C_\ell(t) \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ k_K \prod_{\{\ell : b_{K\ell}=1\}} C_\ell(t) \end{bmatrix},$$

and P^T is the transpose of P.

Taking equation (III.4) as our starting point, we permit F to be time-varying (i.e., k_j are replaced by $k_j(t)$) and add first order perturbations due to stationary sources, $\dot{C}_S(t)$, traffic sources, $\dot{C}_T(t)$, and the rate of change of column volume, $\dot{C}_V(t)$, to derive the pollutant column concentration differential equations:

$$\dot{C}(t) = P^T R(t) + \dot{C}_S(t) + \dot{C}_T(t) + \dot{C}_V(t),$$

$$C(0) = C_o$$

where

$$\dot{C}_V(t) = \begin{cases} 0 \text{ if } \dot{h}_m \leq 0 \\ \dfrac{-\dot{h}_m}{h_m} C(t) \text{ if } \dot{h}_m > 0 \end{cases}$$

3. Units

All concentrations are in parts per hundred million except CO, which is in ppm. Rates of change of concentration are in pphm • min^{-1} and h_m

(mixing depth) is in meters.

D. EMISSION MODULE

1. Introduction

The emission module computes the contributions to the pollutant column of street vehicular traffic, freeway traffic and stationary area sources. In characterizing the module, the Los Angeles Basin is subdivided into a grid system of 650 equal 4-square-mile squares corresponding to a 50-by-52-mile square total area. To each of these grid areas is assigned the total number of vehicular freeway and non-freeway miles travelled daily; and the rate of emission in kilograms per hour of reactive hydrocarbons, nitric oxide*, and less reactive hydrocarbons from area sources. The traffic section of the routine requires emission factors in grams/vehicle mile for reactive hydrocarbons, nitric oxide, carbon monoxide, and less reactive hydrocarbons.

The inputs to the module are the time(t), the position of the pollutant column (x,y), the mixing depth (h_m), the emission distributions described above, emission factors described above, and diurnal usage curves. The diurnal curves are illustrated in Figures II.5 and II.6. The grid distributions are shown in Figures II.7 - II.11.

The module's outputs include the emissions from the five sources

street traffic freeway traffic	vehicular sources
reactive hydrocarbons (propylene) nitric oxide less reactive hydrocarbons	area source emissions

in propylene, nitric oxide, carbon monoxide, and less reactive hydrocarbons. These results are given in both pphm/min and gram-moles/min.

---

*Oxides of nitrogen taken as nitric oxide

2. Derivations

Given the air parcel or column location (x,y) (in miles) such that $17 \le x \le 67$ and $1 \le y \le 53$, the projection of the column centroid falls in grid sub-area i, where is is computed according to:

$$i = \left[\frac{x+1}{2}\right] + 25\left[\frac{y+1}{2} - 1\right] - 8$$

where [z] = integer part of z.

Once the primary grid square is selected, the program determines the three next closest grids to the pollutant column; that is, the three grids whose midpoints are nearest the column. At this point, the emissions attributable to the column are computed utilizing values from four grids. The contribution to each of the sources for each of the pollutants is calculated on the basis of the distance of the grid midpoint to the pollutant column and is inversely proportional to the square of this distance. These contributions are then modified by the appropriate diurnal usage curves.

3. Units

All computations are calculated in metric units with the exception of distances which remain in miles.

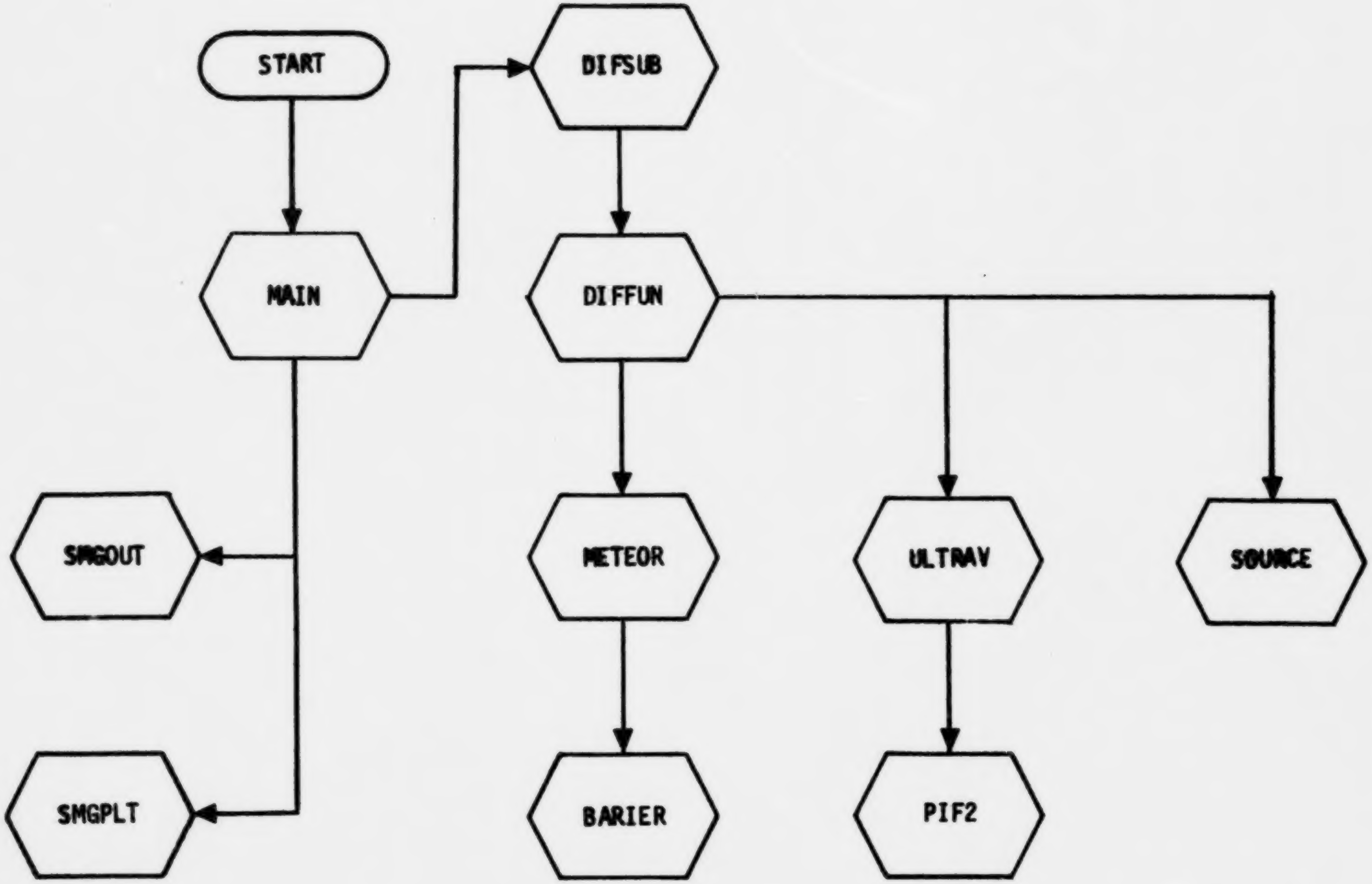
E. NUMERICAL INTEGRATION

DIFSUB is the numerical integration program. It is more commonly known as the Gear routine named after its developer, Professor C. W. Gear of the University of Illinois.

This routine has three numerical integration routines imbedded in it. REM utilizes the option known as the Adams method.

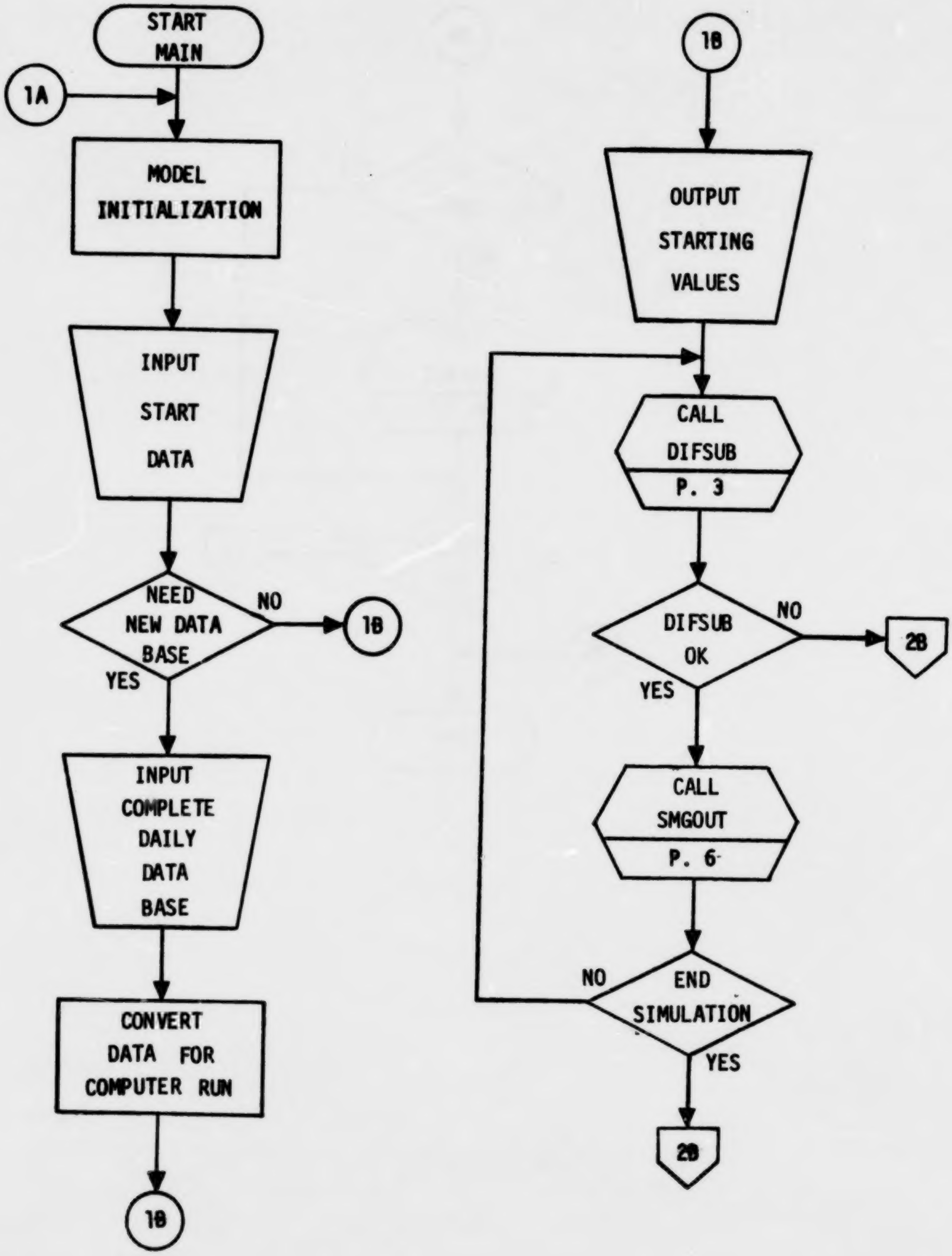
No flowchart or other descriptive material is provided for DIFSUB since this routine was not programmed by PES staff. For additional information contact Professor Gear at the Department of Computer Science, University of Illinois; or see the Communications of the Association for Computing Machinery, March, 1971.

Section IV
Flowcharts

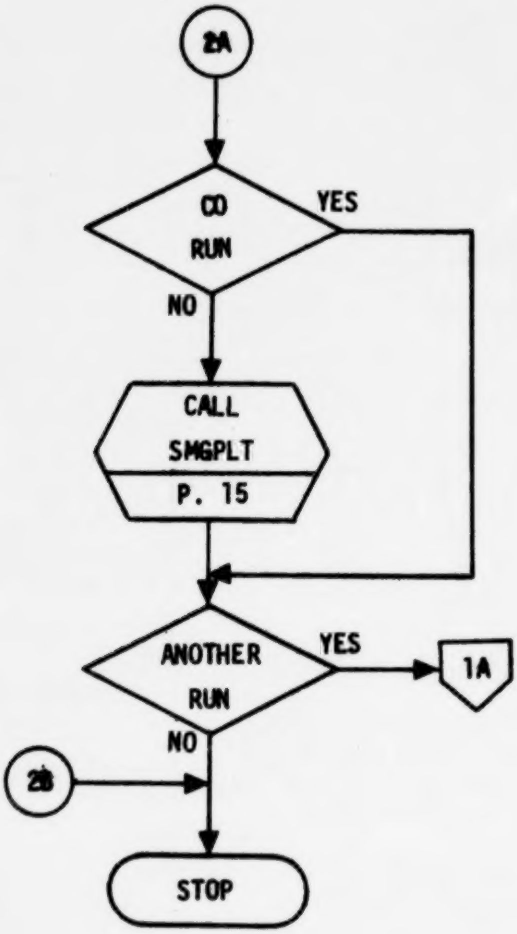


OVERVIEW OF REM

IV.3



FLOW OF MAIN PROGRAM

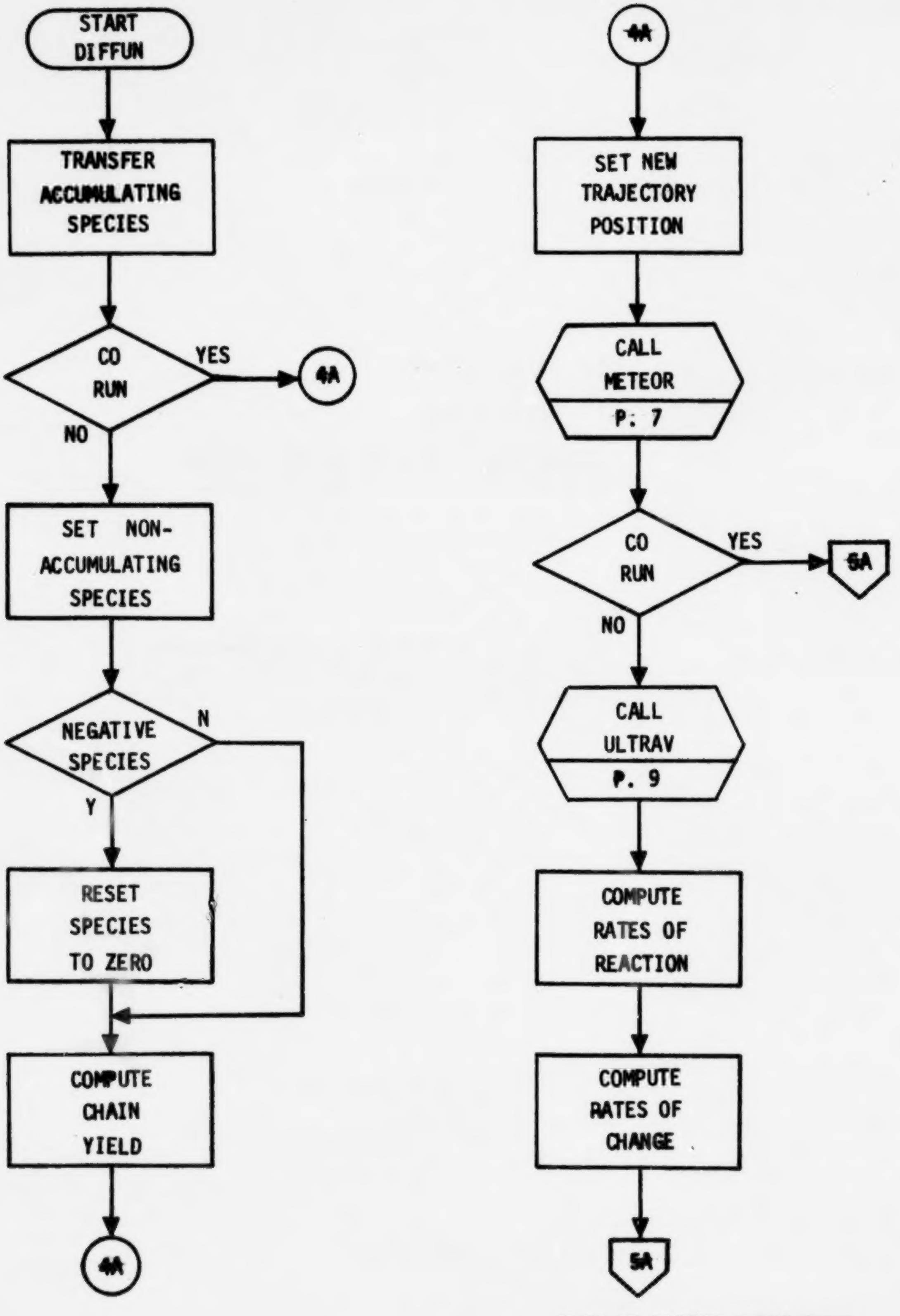

2A
CO RUN
YES
NO
CALL SMGPLT
P. 15
ANOTHER RUN
YES
1A
NO
2B
STOP

DIFSUB*

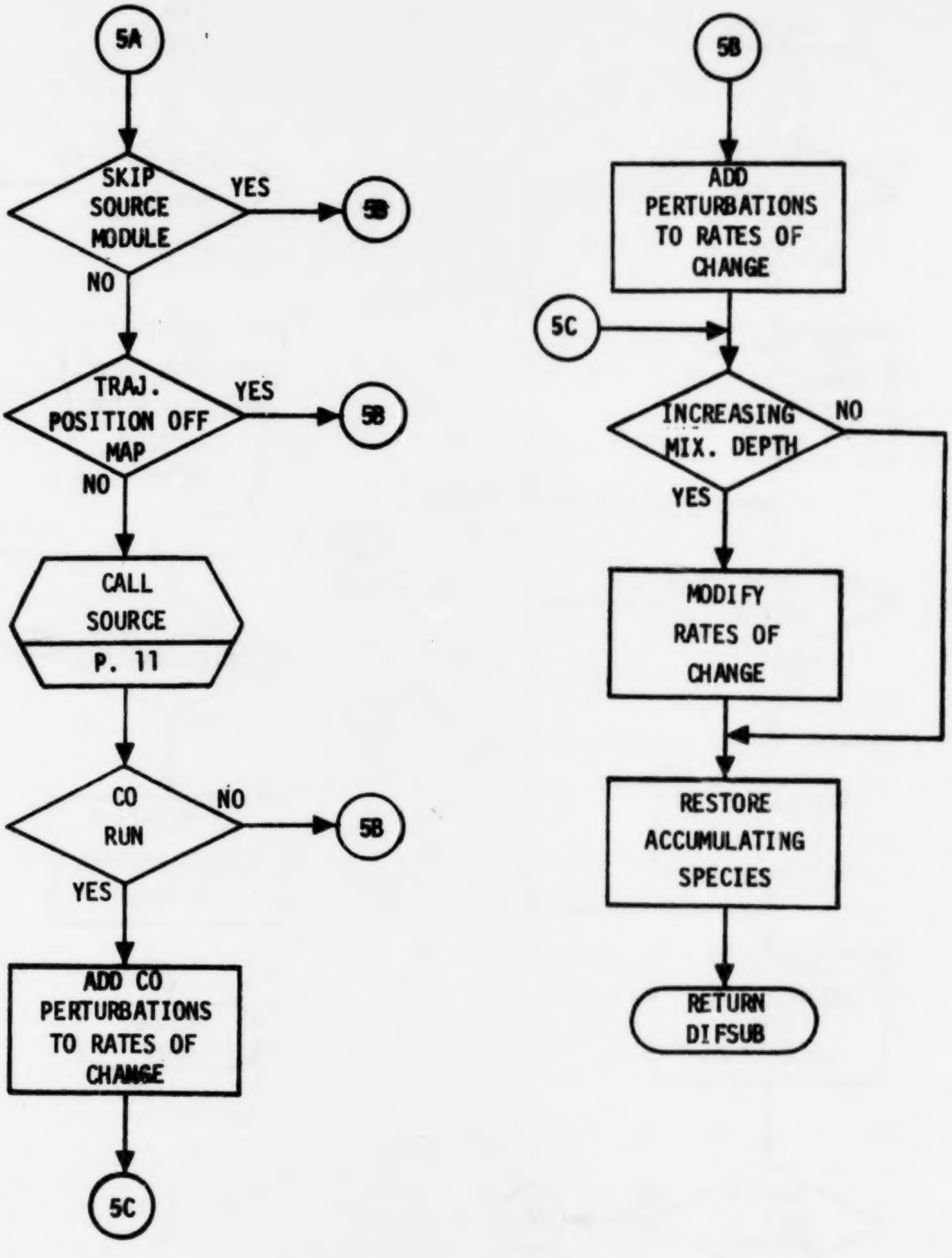
1. Called by MAIN
2. Calls DIFFUN

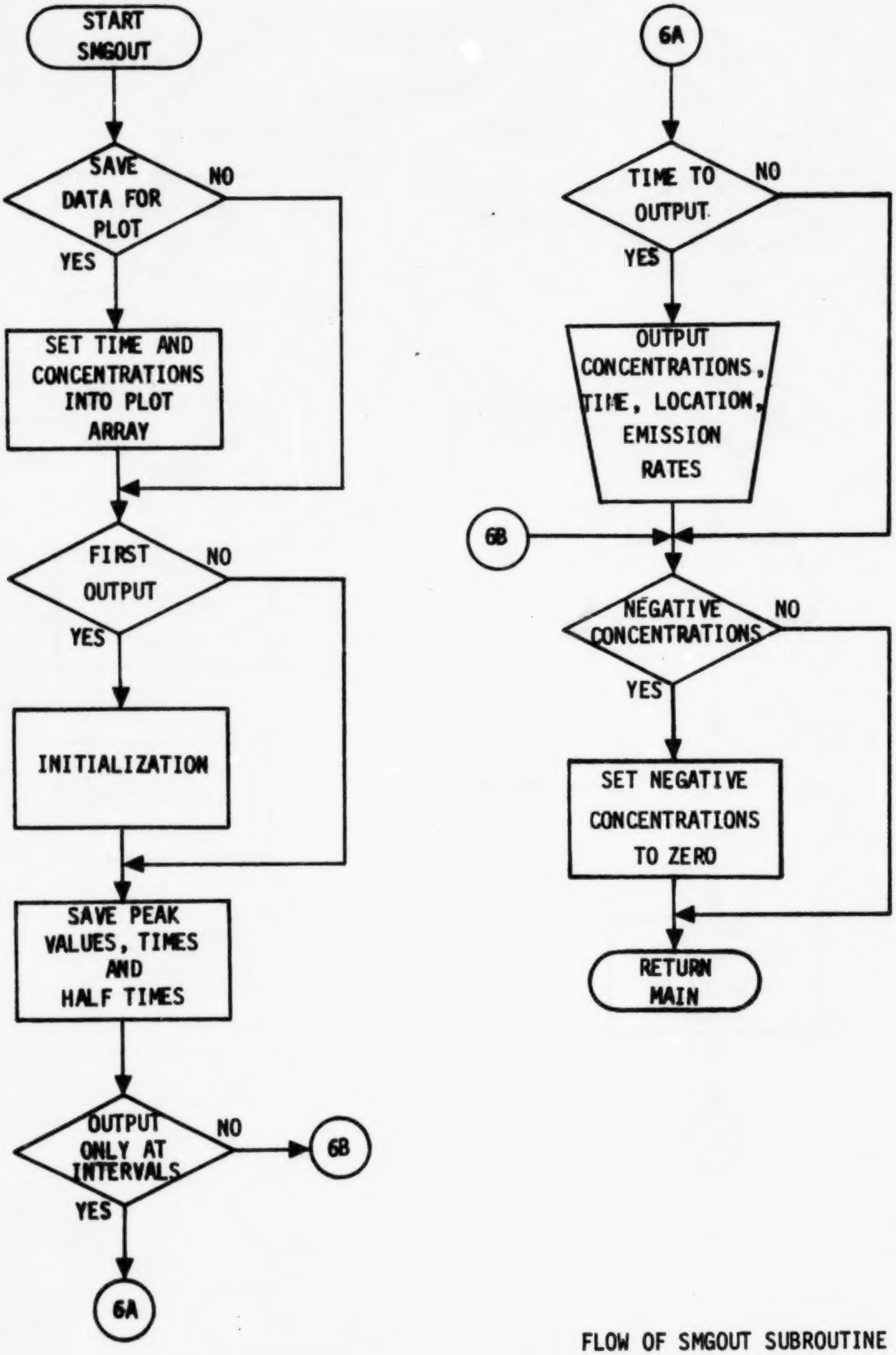
DIFSUB always returns to the calling program after completing its tasks.

*Flowchart of DIFSUB not provided since no programming was done on this routine by PES.

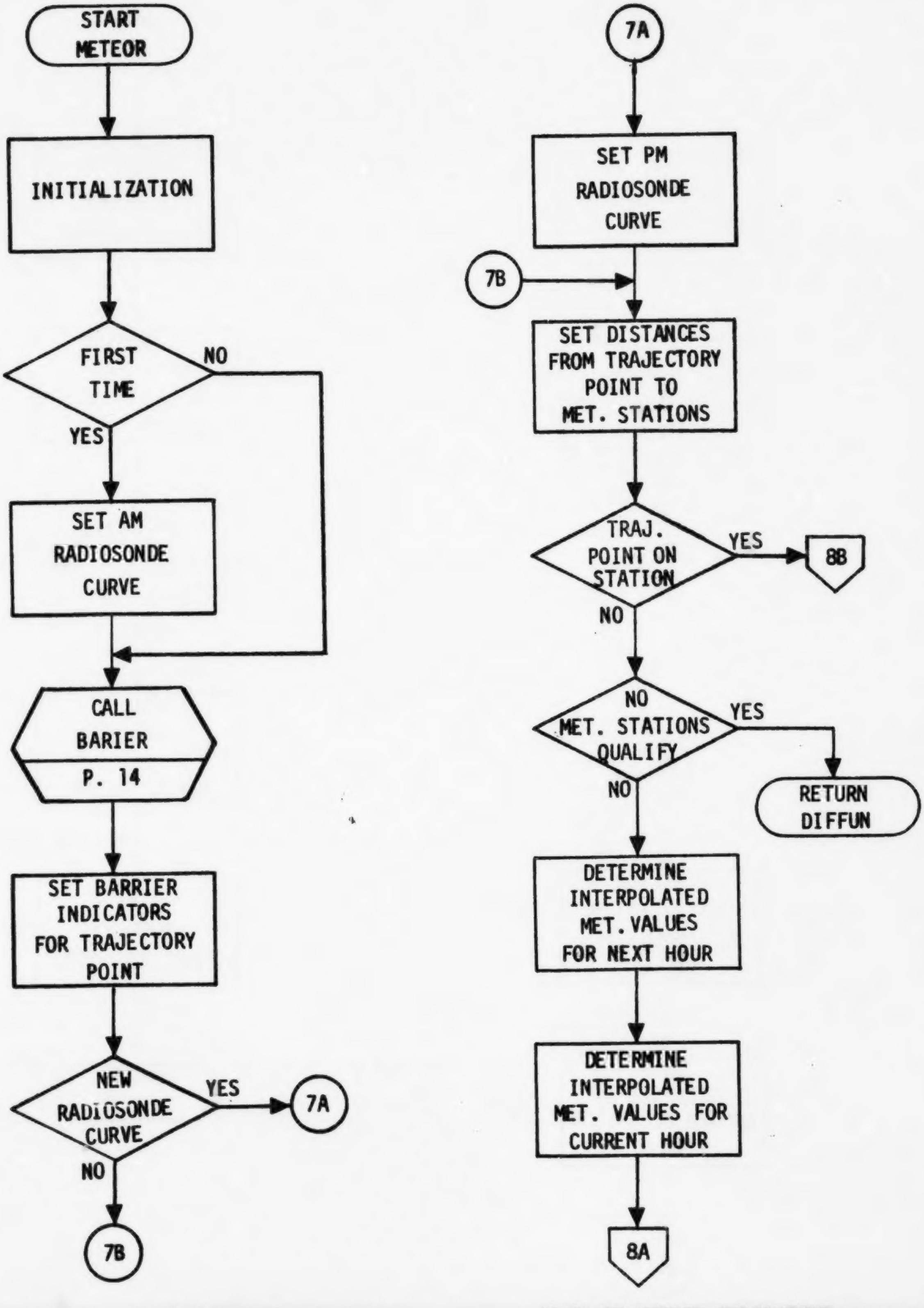


FLOW OF DIFFUN SUBROUTINE

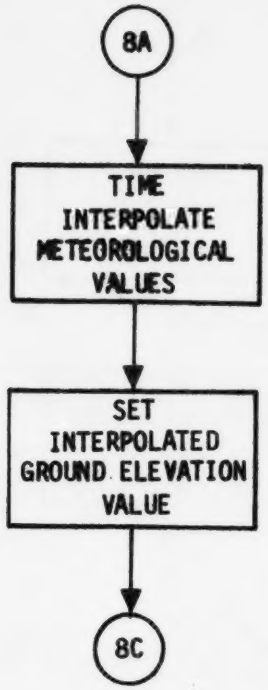

5A
SKIP SOURCE MODULE
YES
5B
NO
TRAJ. POSITION OFF MAP
YES
5B
NO
CALL SOURCE
P. 11
CO RUN
NO
5B
YES
ADD CO PERTURBATIONS TO RATES OF CHANGE
5C
5B
ADD PERTURBATIONS TO RATES OF CHANGE
5C
INCREASING MIX. DEPTH
NO
YES
MODIFY RATES OF CHANGE
RESTORE ACCUMULATING SPECIES
RETURN DIFSUB

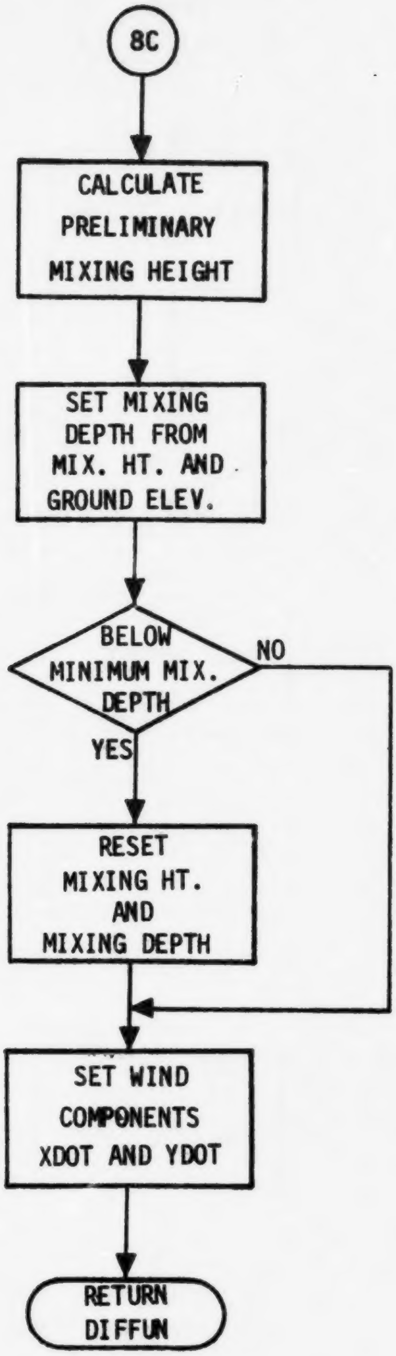

START SMGOUT
SAVE DATA FOR PLOT
NO
YES
SET TIME AND CONCENTRATIONS INTO PLOT ARRAY
FIRST OUTPUT
NO
YES
INITIALIZATION
SAVE PEAK VALUES, TIMES AND HALF TIMES
OUTPUT ONLY AT INTERVALS
NO
6B
YES
6A
6A
TIME TO OUTPUT
NO
YES
OUTPUT CONCENTRATIONS, TIME, LOCATION, EMISSION RATES
6B
NEGATIVE CONCENTRATIONS
NO
YES
SET NEGATIVE CONCENTRATIONS TO ZERO
RETURN MAIN

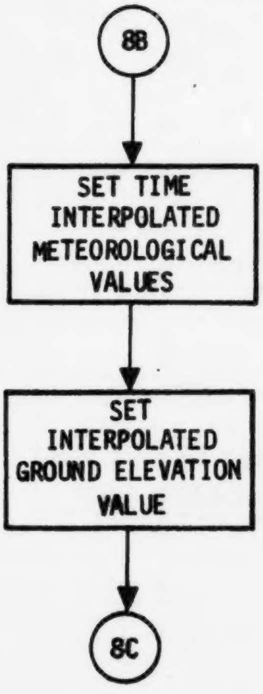
FLOW OF SMGOUT SUBROUTINE

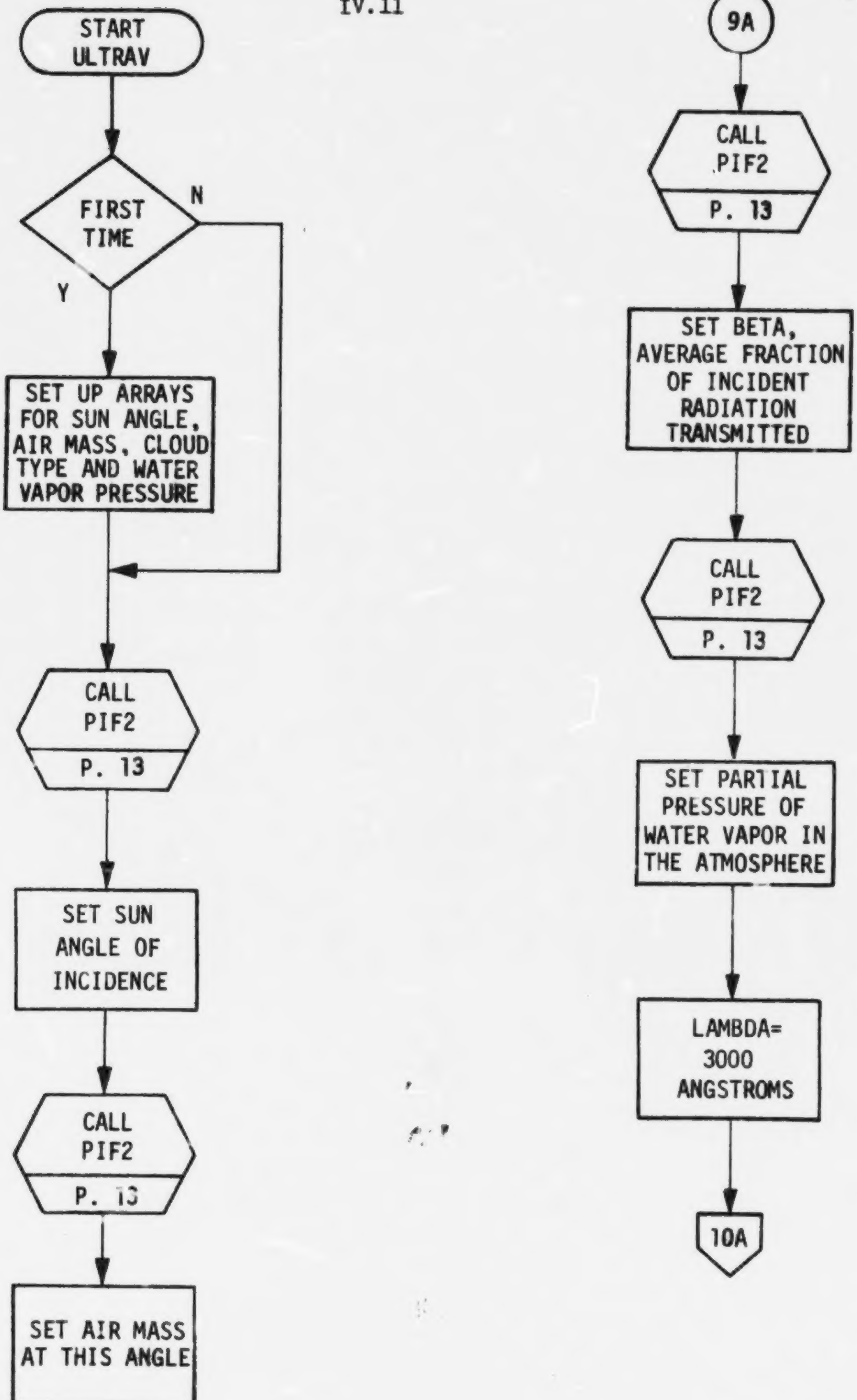


FLOW OF METEOR SUBROUTINE


8A
TIME INTERPOLATE METEOROLOGICAL VALUES
SET INTERPOLATED GROUND ELEVATION VALUE
8C

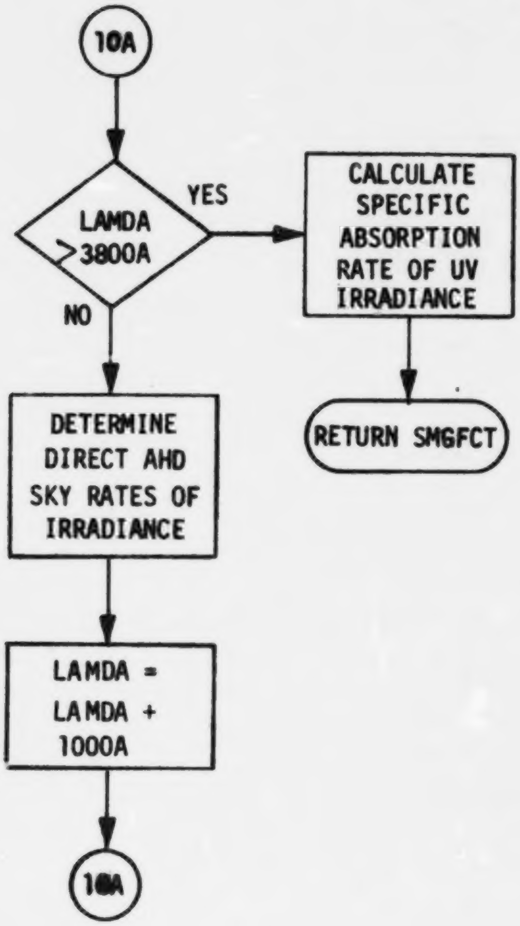

8C
CALCULATE PRELIMINARY MIXING HEIGHT
SET MIXING DEPTH FROM MIX. HT. AND GROUND ELEV.
BELOW MINIMUM MIX. DEPTH
NO
YES
RESET MIXING HT. AND MIXING DEPTH
SET WIND COMPONENTS XDOT AND YDOT
RETURN DIFFUN

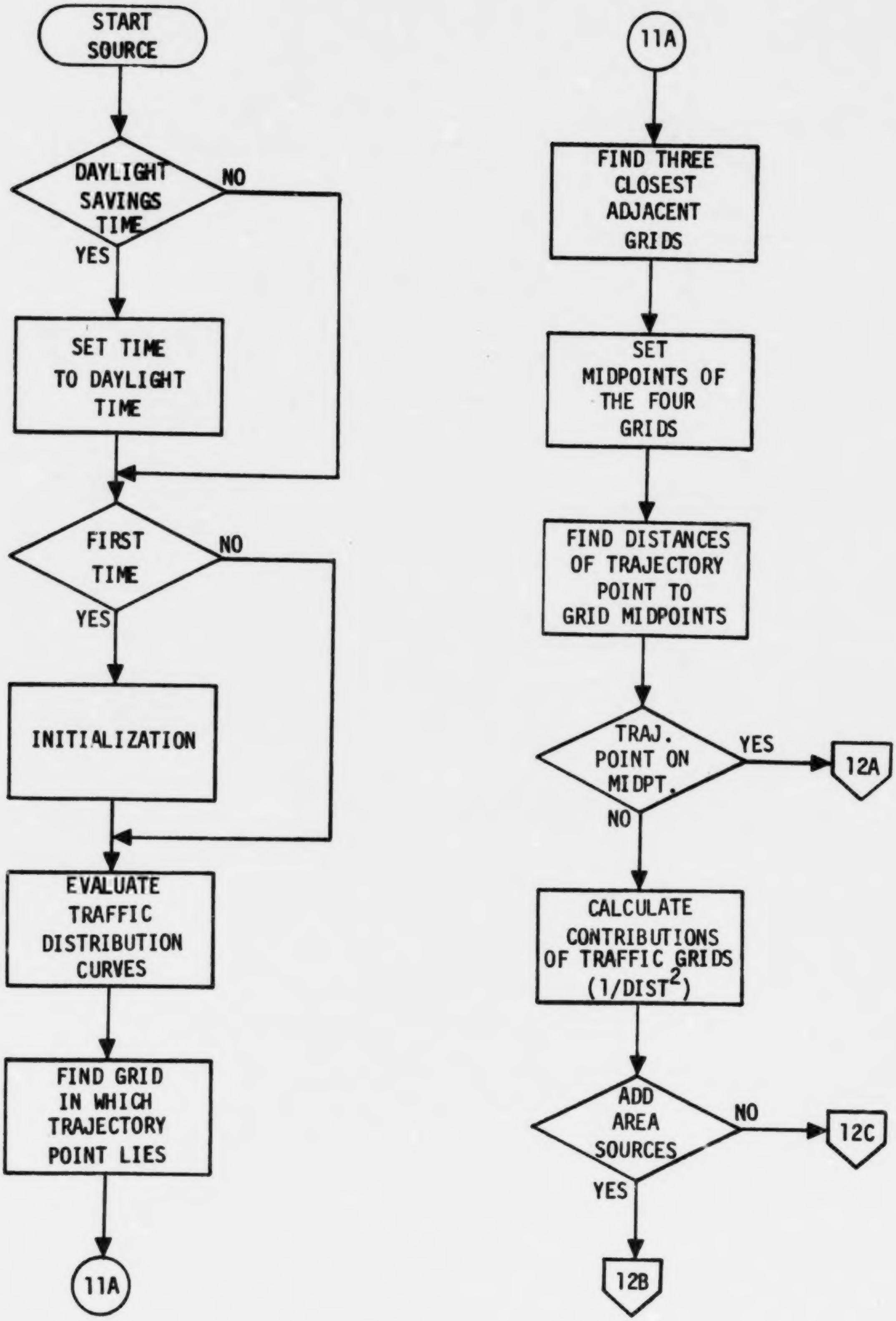

8B
SET TIME INTERPOLATED METEOROLOGICAL VALUES
SET INTERPOLATED GROUND ELEVATION VALUE
8C


START ULTRAV
FIRST TIME
N
Y
SET UP ARRAYS FOR SUN ANGLE, AIR MASS, CLOUD TYPE AND WATER VAPOR PRESSURE
CALL PIF2
P. 13
SET SUN ANGLE OF INCIDENCE
CALL PIF2
P. 13
SET AIR MASS AT THIS ANGLE
9A
9A
CALL PIF2
P. 13
SET BETA, AVERAGE FRACTION OF INCIDENT RADIATION TRANSMITTED
CALL PIF2
P. 13
SET PARTIAL PRESSURE OF WATER VAPOR IN THE ATMOSPHERE
LAMBDA= 3000 ANGSTROMS
10A

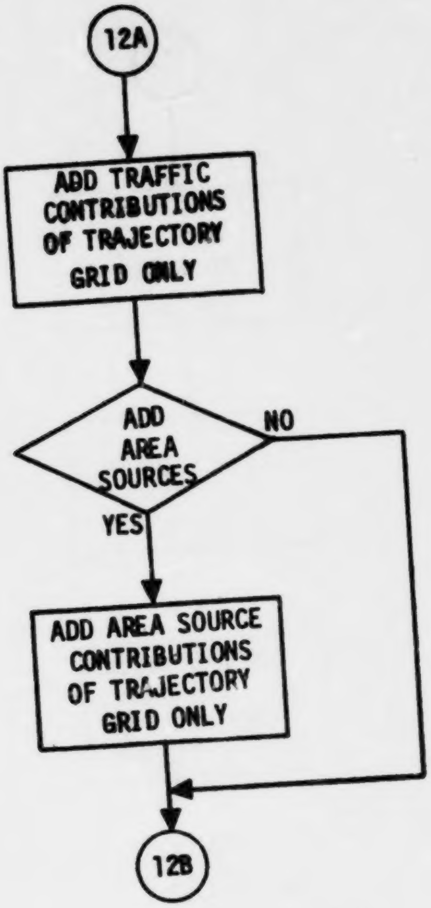
FLOW OF ULTRAV SUBROUTINE

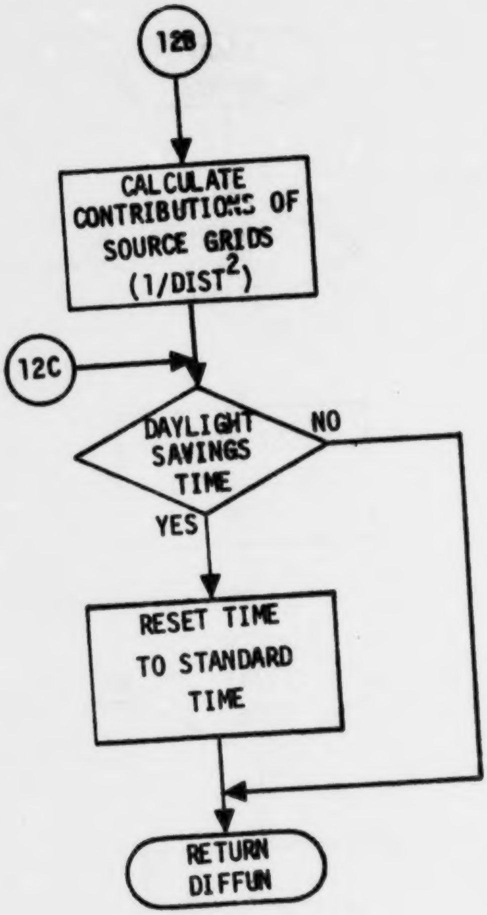
IV.12

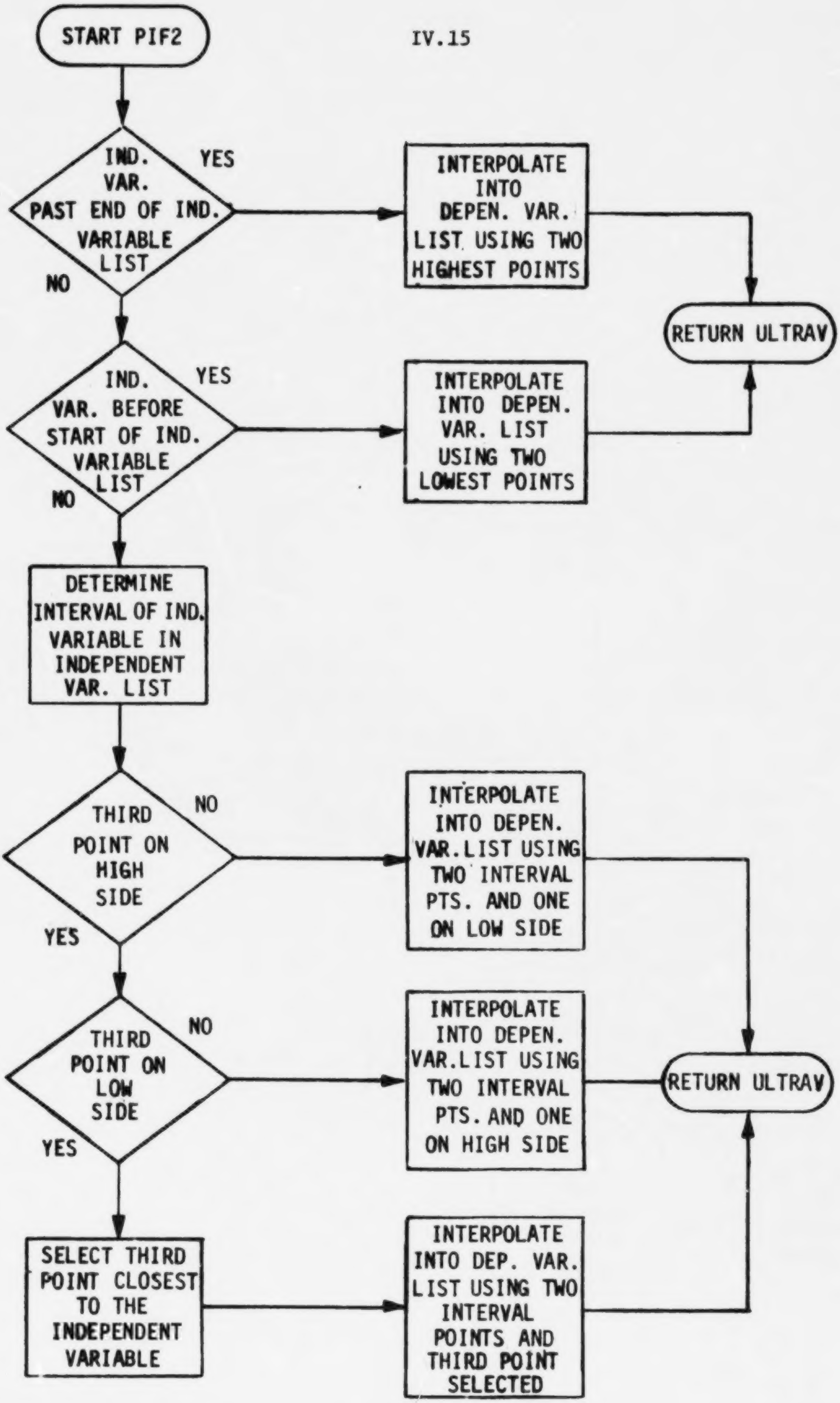

10A
LAMDA >3800A
YES
NO
CALCULATE SPECIFIC ABSORPTION RATE OF UV IRRADIANCE
RETURN SMGFCT
DETERMINE DIRECT AHD SKY RATES OF IRRADIANCE
LAMDA = LAMDA + 1000A
10A


START SOURCE
DAYLIGHT SAVINGS TIME
NO
YES
SET TIME TO DAYLIGHT TIME
FIRST TIME
NO
YES
INITIALIZATION
EVALUATE TRAFFIC DISTRIBUTION CURVES
FIND GRID IN WHICH TRAJECTORY POINT LIES
11A
11A
FIND THREE CLOSEST ADJACENT GRIDS
SET MIDPOINTS OF THE FOUR GRIDS
FIND DISTANCES OF TRAJECTORY POINT TO GRID MIDPOINTS
TRAJ. POINT ON MIDPT.
YES
12A
NO
CALCULATE CONTRIBUTIONS OF TRAFFIC GRIDS (1/DIST^2)
ADD AREA SOURCES
NO
12C
YES
12B

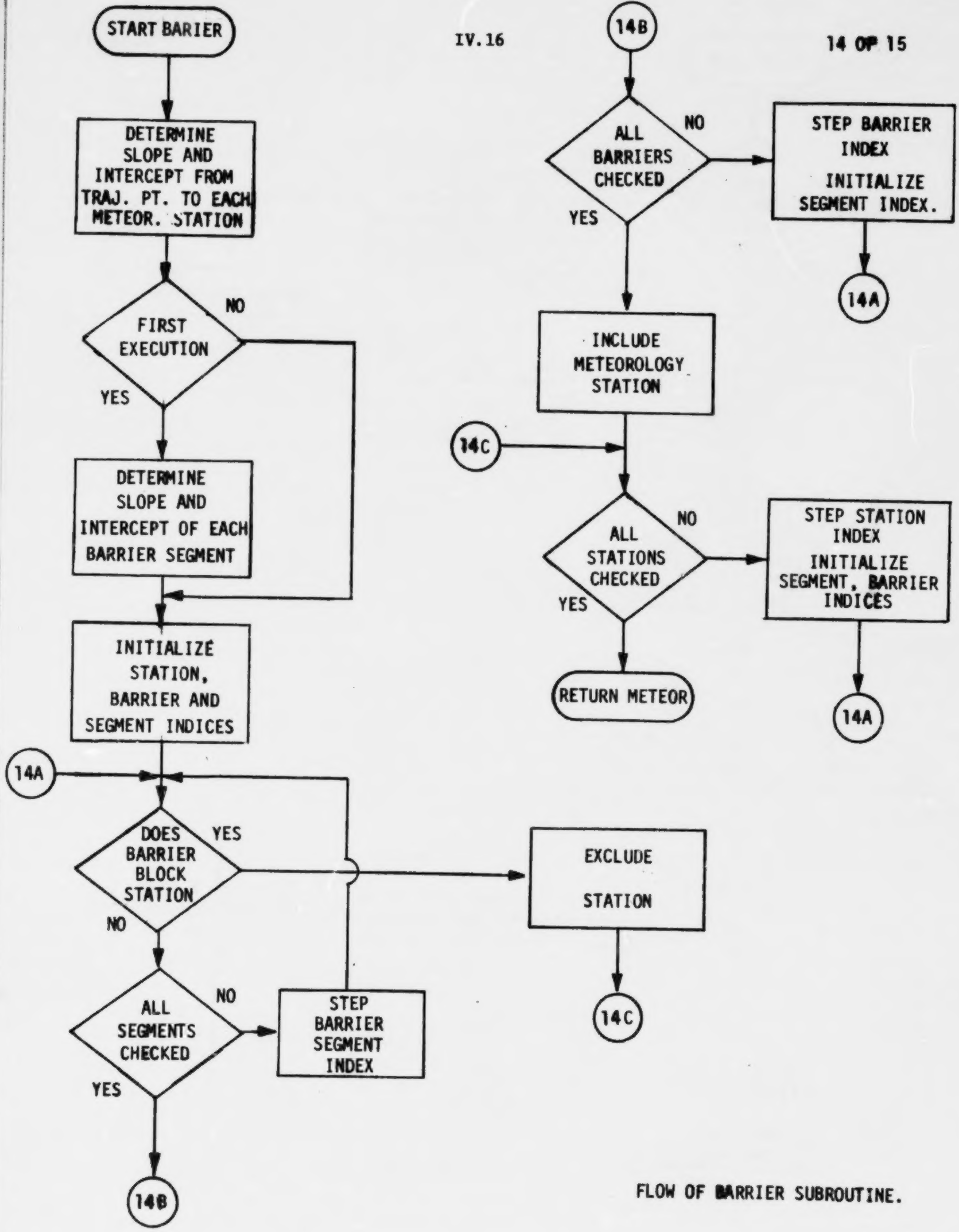
FLOW OF SOURCE SUBROUTINE


12A
ADD TRAFFIC CONTRIBUTIONS OF TRAJECTORY GRID ONLY
ADD AREA SOURCES
NO
YES
ADD AREA SOURCE CONTRIBUTIONS OF TRAJECTORY GRID ONLY
12B

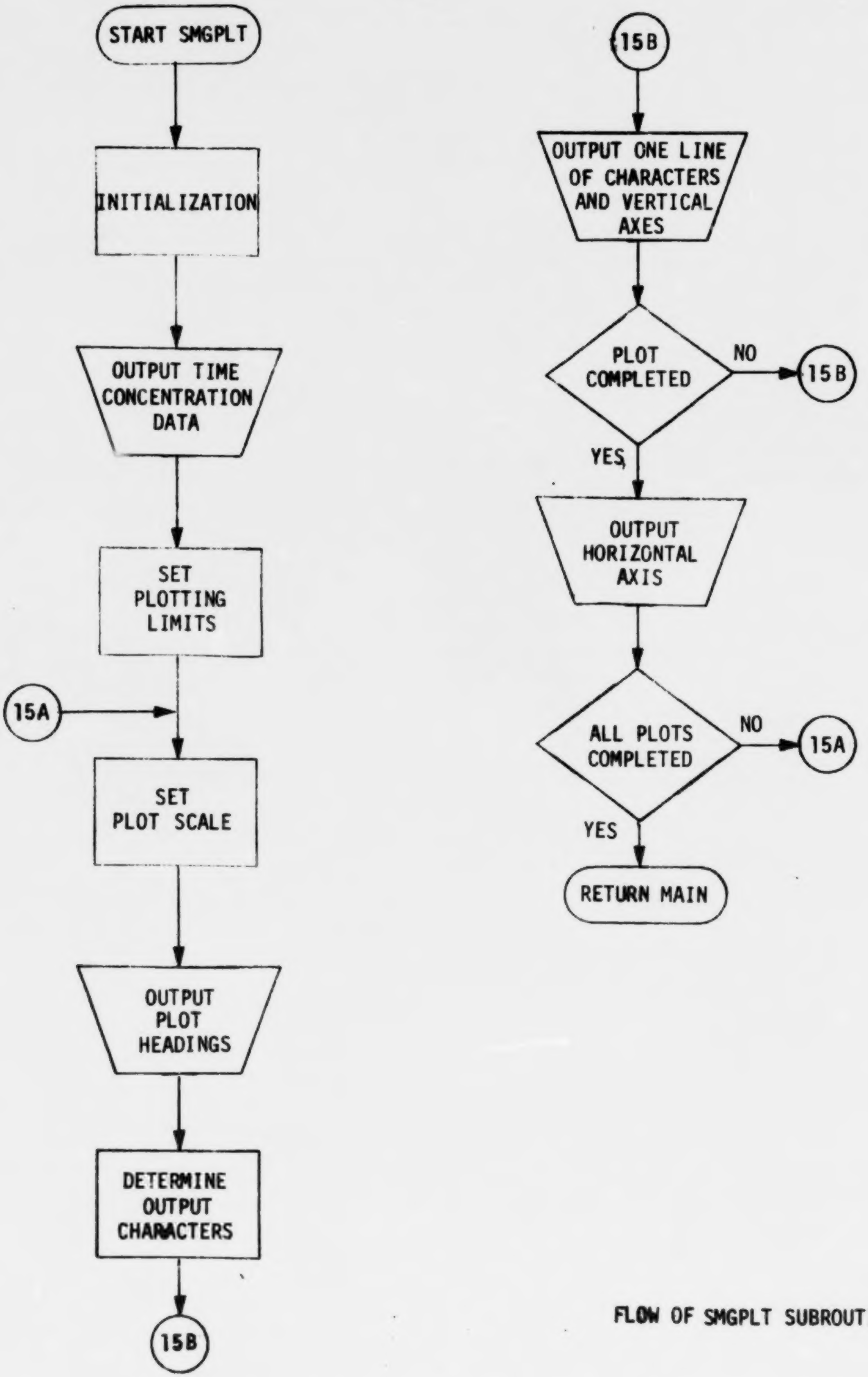

12B
CALCULATE CONTRIBUTIONS OF SOURCE GRIDS (1/DIST^2)
12C
DAYLIGHT SAVINGS TIME
NO
YES
RESET TIME TO STANDARD TIME
RETURN DIFFUN


START PIF2
IND. VAR. PAST END OF IND. VARIABLE LIST
YES
NO
INTERPOLATE INTO DEPEN. VAR. LIST USING TWO HIGHEST POINTS
RETURN ULTRAV
IND. VAR. BEFORE START OF IND. VARIABLE LIST
YES
NO
INTERPOLATE INTO DEPEN. VAR. LIST USING TWO LOWEST POINTS
DETERMINE INTERVAL OF IND. VARIABLE IN INDEPENDENT VAR. LIST
THIRD POINT ON HIGH SIDE
NO
YES
INTERPOLATE INTO DEPEN. VAR.LIST USING TWO INTERVAL PTS. AND ONE ON LOW SIDE
THIRD POINT ON LOW SIDE
NO
YES
INTERPOLATE INTO DEPEN. VAR.LIST USING TWO INTERVAL PTS. AND ONE ON HIGH SIDE
RETURN ULTRAV
SELECT THIRD POINT CLOSEST TO THE INDEPENDENT VARIABLE
INTERPOLATE INTO DEP. VAR. LIST USING TWO INTERVAL POINTS AND THIRD POINT SELECTED

FLOW OF PIF2 SUBROUTINE.


START BARIER
DETERMINE SLOPE AND INTERCEPT FROM TRAJ. PT. TO EACH METEOR. STATION
FIRST EXECUTION
NO
YES
DETERMINE SLOPE AND INTERCEPT OF EACH BARRIER SEGMENT
INITIALIZE STATION, BARRIER AND SEGMENT INDICES
14A
DOES BARRIER BLOCK STATION
YES
NO
ALL SEGMENTS CHECKED
NO
YES
STEP BARRIER SEGMENT INDEX
14B
14B
ALL BARRIERS CHECKED
NO
YES
STEP BARRIER INDEX
INITIALIZE SEGMENT INDEX.
14A
INCLUDE METEOROLOGY STATION
14C
ALL STATIONS CHECKED
NO
YES
STEP STATION INDEX
INITIALIZE SEGMENT, BARRIER INDICES
14A
RETURN METEOR
EXCLUDE STATION
14C

FLOW OF BARRIER SUBROUTINE.



FLOW OF SMGPLT SUBROUTINE.

Section V
Model Inputs

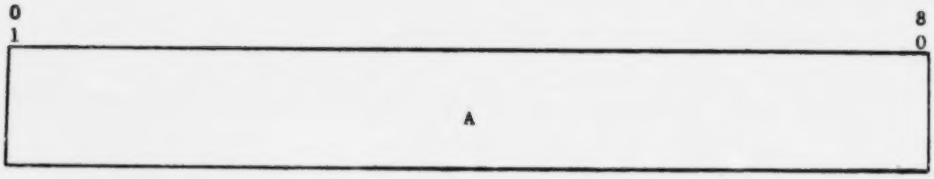
Model inputs must be prepared exactly as described. A complete sample input deck is shown in Section VI.

1. Card Type 1

Heading data---1 array---4 cards.

a. Alphanumeric data used as heading information. May be blank cards.

FORMAT (20A4)



2. Card Type 2

Starting data---4 items---1 card.

XPOS - X coordinate of starting position in miles. Range: 17.0 to 67.0. Cols 1-10.

YPOS - Y coordinate of starting position in miles. Range: 1.0 to 53.0. Cols 11-20.

GOTIME - Simulation start time (local standard time) in hours and decimal fraction hours. Range: 7.000 to 18.999. Cols 21-30.

XMIN - Minimum mixing depth in meters. Current value used is generally 50 meters. Cols. 31-40.

FORMAT (4F10.3)

0	11	22	33	44	8
1	01	01	01	01	0
XPOS	YPOS	GOTIME	XMIN		

3. Card Type 3

Starting data---6 items---1 card.

PRMT (2) - Length of simulation in minutes and decimal fraction of minutes. Cols. 1-10.

PRMT (3) - Minimum step size for numerical integration in decimal fraction of minutes. Normal range is from .000001 to .001. Cols. 11-20.

PRMT (4) - Maximum step size for numerical integration in minutes and decimal fraction of minutes. Normal range is from 0.1 to 20.0 minutes. Cols. 21-30.

PRMT (5) - Initial value of step size for numerical integration in minutes and decimal fraction of minutes. Normal range is from .0001 to .01 minutes. Cols. 31-40.

PRMT (6) - Error criteria for numerical integration in decimal fraction of minutes. Normal range is from .0001 to .10 minutes. Cols. 41-50.

PRMT (7) - Indicator for plot routine. Determines how often data is to be saved for output in the plot. Reasonable value is usually .25*PRMT (2) in minutes. For example, if PRMT (2) is 300.0 minutes, then PRMT (7) would be 75.0. Cols. 51-60.

FORMAT (6F10.3)

0 1	11 01	22 01	33 01	44 01	55 01	66 01	8 0
PRMT(2)	PRMT(3)	PRMT(4)	PRMT(5)	PRMT(6)	PRMT(7)		

4. Card Type 4

Starting data---14 items---1 card (all values must be right justified.

NDIM - Number of accumulating species. For CO simulation only, value must be 1. Cols. 1-5.

NC - Total number of species. For CO simulation only, value must be 3. Cols. 6-10.

NEQ - Number of elementary steps in mechanism. For CO simulation only, value must be 1. Cols. 11-15.

NLL - Number of lines to be used in plots, 0 gives 50 lines. Cols 16-20

NSTA - Number of meteorological stations. Cols. 21-25.

MF - Indicator for numerical integration method. Range: 0 to 2; values are: 0 - Adam's method
1 - Gear (matrix inversion) for less than 5 equations
2 - Gear (Gaussian elimination and back substitution) for 5 or more equations. Cols. 26-30.

MAXDER - Maximum number of derivatives calculated. Use MAXDER=12 if MF=0, or use MAXDER=6 if MF=1 or 2. Cols. 31-35.

ICLOUD - Index which defines seven different cloud types for ultraviolet radiation module.[1] Range: 2 to 8, values are:

---

[1] Leighton, Phillip A., Photochemistry of Air Pollution, Academic Press, New York, 1961, Page 40, Table 10.

2 - cirrus

3 - Cirrostratus

4 - Altocumulus

5 - Altrostratus

6 - Stratocumulus

7 - Stratus

8 - Fog

Cols. 36-40.

NRAD - Number of radiosonde points (maximum = 15) in the curve describing the mixing height. Cols. 41-45.

ITRAF - Traffic module operation indicator. 0 - module does not operate, 1 - module operates. Cols. 46-50.

ISOUR - Area source module operation indicator. 0 - module does not operate, 1 - module operates. Cols. 51-55.

IHT - Indicates if mixing height is entered by way of radiosonde data, or if it is input directly in meters. 0 - radiosonde data, 1 - input mixing height. Cols. 56-60.

IN - Indicates if model is to operate again with data from the previous run or a new set of data is necessary. 0 - a complete set of data is necessary for the run, 1 - return with the previous data. Must input only card types 1, 2, 3, 4, 5, 6 and 7. Need card type 6 only if IHT = 1. Cols. 61-65.

IPST - Time indicator. 0 - traffic module operates on daylight time, 1 - traffic module operates on standard time, Cols. 66-70.

FORMAT (14I5)

0 1	00 56	11 01	11 56	22 01	22 56	33 01	33 56	44 01	44 56	55 01	55 56	66 01	66 56	77 01	8 0
NDIM	NC	NEQ	NLL	NSTA	MF	MAXDER	ICLOUD	NRAD	ITRAF	ISOUR	IHT	IN	IPST		

5. Card Type 5

Output data---1 item---1 array---1 card.

INTR - Integer. Positive value causes outputs at approximate times specified in array STEP. Zero or negative value causes outputs each time through. Cols. 1-2.

STEP - Array of up to 15 times for output in minuts. Output usually occurs within 1/2 minute of time specified. Cols. 6-80.

FORMAT (I2, 3X, 15F5.2)

000 123	00 56	11 01	11 56	22 01	22 56	33 01	33 56	44 01	44 56	55 01	55 56	66 01	66 56	77 01	77 56	8 0
INTR		STEP (1)	STEP (2)	STEP (3)	STEP (4)	STEP (5)	STEP (6)	STEP (7)	STEP (8)	STEP (9)	STEP (10)	STEP (11)	STEP (12)	STEP (13)	STEP (14)	STEP (15)

6. Card Type 6

Mixing height data---1 array---1 card

XHITE - Array of up to 12 values of mixing height in meters. Cols. 1-72, optional (used only if IHT is set to 1; see IHT, card type 4). Represent hours 0700 to 1800, respectively.

FORMAT (12F6.0)

0 1	00 67	11 23	11 89	22 45	33 01	33 67	44 23	44 89	55 45	66 01	66 67	77 23 … 8 0
XHITE (1)	XHITE (2)	XHITE (3)	XHITE (4)	XHITE (5)	XHITE (6)	XHITE (7)	XHITE (8)	XHITE (9)	XHITE (10)	XHITE (11)	XHITE (12)	

7. Card Type 7

Species data--2 arrays--$\left[\frac{NC}{4}\right]$[*] + 1 cards, 4 species per card

LABEL - Alphanumeric array of NC[**] species names. Cols. 1-8, 21-28, 41-48, 61-68.

Y[#]- NC double precision values of initial species concentrations in pphm, except CO is in ppm. Cols. 9-20, 29-40, 49-60, 69-80.

0 1	00 89	22 01	22 89	44 01	44 89	66 01	66 89 … 8 0
LABEL	Y	LABEL	Y	LABEL	Y	LABEL	Y

8. Card Type 8

Sun Angle Data---1 array---2 cards

ZENITH - Twelve pairs of an hour in standard time coupled with the sun angle at that time. Hour in cols [illegible]5, 11-15, 21-25, 31-35, 41-45, 51-55, 61-65, 71-75. Sun angle in cols. 6-10, 16-20, 26-30, 36-40, 46-50, 56-60, 66-70, 76-80. Pairs carry

---

[*] [ ] means largest integer.

[**] See card type 4.

[#] C_3H_6 is set to .015 x CO in pphm

DUMHC is set to .15 x CO in pphm

over onto second card.

0 1	00 56	11 01	11 56	22 01	22 56	33 01	33 56	44 01	44 56	55 01	55 56	66 01	66 56	77 01	77 56	8 0
Z (1,1) Hour	Z (1,2) Angle	Z (2,1) Hour	Z (2,2) Angle	Z (3,1) Hour	Z (3,2) Angle	Z (4,1) Hour	Z (4,2) Angle	Z (5,1) Hour	Z (5,2) Angle	Z (6,1) Hour	Z (6,2) Angle	Z (7,1) Hour	Z (7,2) Angle	Z (8,1) Hour	Z (8,2) Angle	

Z = array ZENITH

0 1	00 56	11 01	11 56	22 01	22 56	33 01	33 56	44 01	8 0
Z (9,1) Hour	Z (9,2) Angle	Z (10,1) Hour	Z (10,2) Angle	Z (11,1) Hour	Z (11,2) Angle	Z (12,1) Hour	Z (12,2) Angle		

Z = array ZENITH

9. Card Type 9

Meteorological data--2 arrays--maximum of 32 stations.

AIR - 3 cards per station, 4 hours per card, 12 hours per station. Cards are as follows:

IDNUM - column 1-3, station ID code

AIR - column 4-5, start hour of data, values are 7, 11 or 15

6, number of readings on card, max = 4

7-23
24-40
41-57
58-74 } hourly data--17 columns

6 items in 17 columns in the following order:

3 columns - wind direction in degrees

3 columns - wind speed in miles/hour, last column is in tenths of a mile/hour

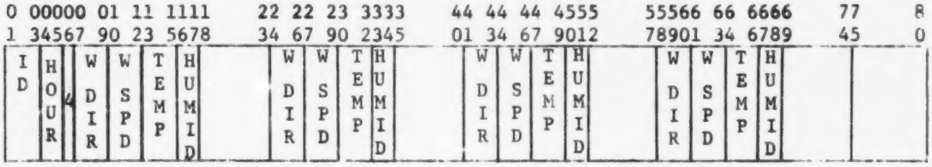
3 columns - temperature in °F

2 columns - dew point in °F

6 columns - blank

FORMAT (A3, 3X, 4(F3.0, F3.1, F3.0, F2.0, 6X), 6X)

Conversion: Wind speed and direction are converted to XDOT and YDOT, the X and Y components of the wind velocity at the column. Temperature is converted to °C. Relative humidity is determined from temperature and dew point. The station order on card types 8 and 9 must be exactly coincidental.



10. Card Type 10

Meteorological Stations--2 arrays--maximum of 8 cards, 4 stations per card

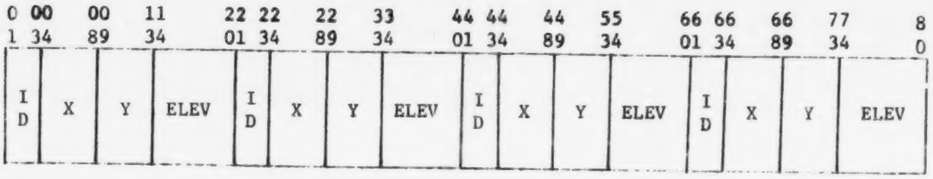
WPOS - Array of triplets, 4 stations per card, maximum of 32 stations. Cards are as follows:

IDMET - column 1-3, alphanumeric station ID code.

WPOS - column 4-8, X coordinate of station position in miles, last 2 columns in hundredths of miles. Column 9-13, Y coordinate of station position in miles, last 2 columns in hundredths of miles. Column 14-20, ground elevation of station in feet, last 2 columns in hundredths of feet. This 20 column grouping is repeated in columns 21-40, 41-60, 61-80 as required, and on additional cards if necessary.

- FORMAT (4(A3, 2F5.2, F7.2))

The station order on card types 9 and 10 must be exactly coincidental.



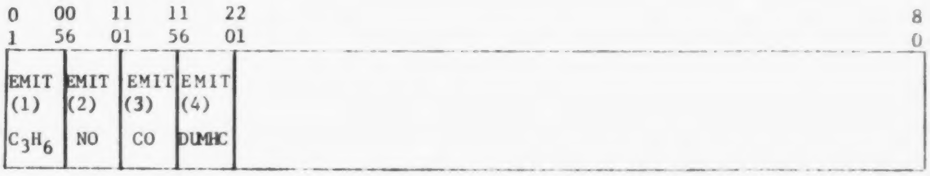
11. Card Type 11

Traffic data---1 array---1 card

EMIT - Array of emission factors in grams per vehicle mile for chemical compounds in the following order:

1 - Propylene (C_3H_6). Cols. 1-5
2 - Nitric oxide (NO). Cols. 6-10
3 - Carbon monoxide (CO). Cols. 11-15
4 - Dummy hydrocarbons (DUMHC). Cols. 16-20

FORMAT (10F5.2)



12. Card Type 12

Omit if ITRAF is not set to 1 (see card type 4)

Vehicular mileage by 4-square mile grid---2 arrays---52 cards

FGRID - 650 values representing the freeway traffic mileage per grid in thousands of miles. 25 values at 3 columns each per card.

SGRID - 650 values representing the street traffic mileage per grid in thousands of vehicular miles. 25 values at 3 columns each per card.

FORMAT (25F3.0)

```
0 00 00 01 11 11 11 22 22 22 33 33 33 34 44 44 44 55 55 55 66 66 66 67 77 77  8
1 34 67 90 23 56 89 12 45 78 01 34 67 90 23 56 89 12 45 78 01 34 67 90 23 56  0
```

GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	GRID	

FGRID and SGRID have the same formats.

13. Card Type 13

Omit if ISOUR is not set to 1 (see card type 4)

Area source emissions by 4-square mile grid---3 arrays---78 cards

AGRID1 - 650 values representing distribution of reactive hydrocarbon (propylene) emissions by grid in units of kilograms per hour. 25 values at 3 columns each per card.

AGRID2 - 650 values representing distribution of nitric oxide (NO) emissions by grid in units of kilograms per hour. 25 values at 3 columns each per card.

AGRID4 - 650 values representing distribution of less reactive hydrocarbons (DUMHC) emissions by grid in units of kilograms per hour. 25 values at 3 columns each per card.

FORMAT (25F3.0)

01-03	04-06	07-09	10-12	13-15	16-18	19-21	22-24	25-27	28-30	31-33	34-36	37-39	40-42	43-45	46-48	49-51	52-54	55-57	58-60	61-63	64-66	67-69	70-72	73-75	76-80
AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	AGRID	

AGRID1, AGRID2, AGRID4 have the same formats.

14. **Card Type 14**

Chemical mechanism data---3 arrays---NEQ* cards (see card type 3)

RCT - Alphanumeric array of NEQ chemical reactions. Cols. 1-24.

IR - 5 integer values per card of species designations. These values reflect the mechanism being used. Columns 25-39, 3 columns per number, right justified.

C - array of NEQ double precision reaction rate constants. Cols. 40-54.

FORMAT (3A8, 5I3, D15.8, 26X)

01-24	25-27	28-30	31-33	34-36	37-39	40-54	55-80
RCT	IR (1)	IR (2)	IR (3)	IR (4)	IR (5)	C	

---

*See card type 4.

15. **Card Type 15**

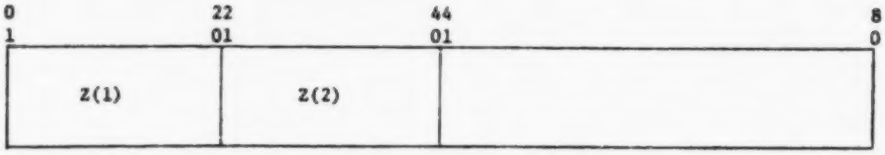
Chemistry parameters---1 array---1 card

Z - Chain termination rate factors

Z(1) Combination of free radicats - current value used is 100.0

Z(2) Combination of radicals with NO - current value used is 0.05

FORMAT (2D20.8)



16. **Card Type 16**

Omit if IHT is 1 (see card type 4)

Radiosonde data---2 arrays---maximum of 8 cards

ARADIO - AM radiosonde curve of NRAD (see card type 4) elevations in meters followed by NRAD temperatures in degrees centigrade. The first temperature is the temperature at the lowest elevation, the second temperature is the one at the next elevation etc. The temperatures must begin on a separate card. If NRAD is greater than 8, two cards must be used for elevation, followed by two for temperature. Ten columns are used for each elevation and temperature. The last column in each field is in tenths of a meter or degree.

PRADIO - PM radiosonde curve of NRAD elevations and temperatures. Data is identical to that for the array ARADIO. If only one radiosonde curve is available, the same one is used for both curves. If two curves are available, the model assumes they have the same number of points.

FORMAT (8F10.1)

0 11 22 33 44 55 66 77 8
1 01 01 01 01 01 01 01 0

ELEV	ELEV	ELEV	ELEV	ELEV	ELEV	ELEV	ELEV

0 11 22 33 44 55 66 77 8
1 01 01 01 01 01 01 01 0

TEMP	TEMP	TEMP	TEMP	TEMP	TEMP	TEMP	TEMP

APRADIO
PRADIO

Section VI

Sample Input Deck for REM

Card Type 1

```
TRAJECTORY RUN ON SEPTEMBER 26, 1972
     SEPTEMBER 30, 1969                  RUN TO POMONA AT 13:30
         390 MINUTE RUN
              25 METEOROLOGICAL STATIONS
```

Card Type 2

```
57.5261   10.9335      7.01       50.0
```

Card Type 3

```
390.0     .0001        0.1       .001       .01      100.0
```

Card Type 4

```
12   25   33    0   25    0   12    2    6    1    1    0    0    0
```

Card Type 5

```
15       0.    0.   30.   60. 100. 140. 180. 220. 260. 300. 330. 360. 380. 386. 389.
```

Card Type 6*

```
80    200    260    220    260    300    315    450    500    460    400    300
```

Card Type 7

```
NO2      0.106302D 02NO        0.364916D 0203        0.168827D 01C3H6      0.25      D 02
HNO3     0.0          CH3CHO   0.0          HCHO     0.0          CO (PPM)0.166638D 02
CH3ONO2  0.0          C2H3NO5  0.0          FIXED O20.0           DUMHC    0.25      D 03
         0.0          H        0.0          OH       0.0          HO2      0.0
CH3      0.0          CH3O     0.0          CH3O2    0.0          C2H3O    0.0
C2H3O2   0.0          C2H4O2   0.0          O        0.0          NO3      0.0
C2H3O3   0.0
```

Card Type 8

```
  6   87    7   74    9   63    9   52   10   42   11   36   12   34   13   38
 14   46   15   57   16   68   17   80
```

*Card type is snown only for illustrative purposes. As a result of inputs shown on Card Type 3, this data should be omitted.

Card Type 9

```
LAX07418  5  66621114  18  6  69641115  24  8  71651119  113 3
LAX11422  8  76641111  24  9  78631103  25 12  79621095  25 13  76611089
LAX15423 13  76601084  25 10  75581074  24 12  73611074  21  8  70631070
BUR07428  3  7052      12  3  7753       9  9  8251       90 7
BUR11415  7  9150      15  9  9158      15  9  9455      15 14  9345
BUR15414  9  9245       9  9  9448      10  9  8651      10  9  8153
LGB074 90 1  65571122  11  3  70601125  17  7  74591125  17  6  68581122
LGB11417  8  80591119  13 12  82571108  17 14  82581098  17 10  84591091
LGB15428 12  87531038  31  8  85521081  10  7  80511078  10  6  73611081
NTB07400 00  64621115  13  2  72621116  19  6  76201117  20  5  80621113
NTB11400 00  0000      22  8  81501104  20 12  82591095  20 13  80581087
NTB15420 13  78621083  20  7  78611075  00 00  0000      17  6  70621073
CAP07418  3            18  3            18  6            18  5
CAP11422  7            22  8            22 13            27 11
CAP15427  6            22  6            22  6            22  6
HOL074225 2            225 2            135 2            225 2            093019
HOL114225 2            225 2            225 1            180 2            093020
HOL154225 2            225 6            225 6            225 2            093021
PIC07427  1            22  2            18  2            18  2
PIC11418  2            18  2            22  1            18  1
PIC15422  1            18  1            18  1            22  1
RLA074 45 1            180 1             45 1            180 1            093025
RLA114180 1            225 1            180 1            225 2            093026
RLA154225 1            225 1            225 1            225 1            093027
VER074180 2            180 3            135 2            135 7            093028
VER114180 9            18010            180 8            18010            093029
VER15422514            225 9            225 7            225 7            093030
WNT074 7  3            11  3            27  3            24  5
WNT11420  7            22  9            20  9            20  8
WNT15420  8            18  6            16  7            16  5
WLA07425  1            18  1            20  2            20  1
WLA11420  2            20  3            22  4            22  5
WLA15422  5            22  3            22  3            22  1
WHT074150 2            158 2            180 3            180 3            093037
WHT114203 3            203 6            203 6            180 7            093038
WHT154158 5            150 4            158 5            158 3            093039
PAS07434  1            13  1             9  3            11  2
PAS11416  3            18  3            20  4            22  7
PAS15420  5            20  3            16  2            16  1
VEN07418  1            16  2            18  2            18  5
VEN11420  5            25  5            22  5            25  6
VEN15420 10            22  5            22  3            13  1
RVA074 45 2             90 3             90 5            158 5            093046
RVA114158 5            158 6            203 8            20310            093047
RVA154225 8            225 6            203 5            203 5            093048
RES07427  1            20  1            20  1            22  3
RES11422  3            27  3            25  6            25  8
RES15427  8            29  6            31  2            11  1
RB 07418  5            20  4            20  2            20  4
RB 11422  5            22  5            22  7            20  7
RB 15420  7            18  7            20  9            20  6
CPK074315 1            248 1            225 1            248 1            093055
CPK114225 2            315 3            293 6            293 6            093056
CPK154315 4            338 4            338 3            158 1            093057
KFI074180 1            135 2            203 3            225 2            093064
KFI114225 5            225 7            225 9            225 8            093065
KFI154203 8            225 6            225 7            225 5            093066
ENC07422  3            24  2            34  2             2  3
ENC11416  4            12  8            18  8            27  8
```

Card Type 9 (continued)

```
ENC15427  9             27  6            29  5             6  4
ELM074315 1             158 1            180 1            180 3             093069
ELM114225 4             203 6            18010            22511             093070
ELM154180 8             18012            180 6            180 8             093071
COM07416  2             29  2            22  3            18  4
COM11422  3             27  7            29  9            29 12
COM15429 14             29 10            29  7            31  8
POM074135 2             180 2            203 2            270 2             093082
POM114270 5             248 6            270 6            248 7             093083
POM154293 5             270 5            270 4            293 3             093084
AZU07413  1             13  2            18  3            18  3
AZU11422  6             22  8            20  9            20 12
AZU15420 13             20  7            20  7            20  3
ONT07436  3  6949       17  5  7753      20  6   7952     27  6   8659
ONT11423  9  8553       28 12  9354      27 14   9344     00 00   0000
ONT15426 16  9161       26 16  8955      00 00   0000     27  9   8156
```

Card Type 10

```
LAX 32    27     99  BUR 33    45    699  LGB 45    18     34  NTB 51    16     27
CAP 40    33    250  HOL 35    37    300  PIC 33    34    100  RLA 45    26    100
VER 41    31    180  WNT 63    30    950  WLA 29    34    200  WHT 51    28    250
PAS 47    42    870  VEN 26    30      5  RVA 48    29    180  RES 22    46    800
RB  31    21     10  MSH 28    48    850  KFI 53    23    100  ENC 24    43    800
ELM 51    35    300  COM 41    23    100  POM 69    34    850  AZU 59    41    600
ONT 72    35    916
```

Card Type 11

```
 2    4   80   16
```

Card Type 12

```
                                                                                F01
                                                               18               F02
                                                               80  6            F03
                                                                   97 95 61 59  F04
                                                            115160163148    91  F05
                                                         153 78       67169 77  F06
                                11 22                181112183150    257131     F07
                               143 45107       529349213 144    25398156161     F08
                               131343545340323195             145 68   137      F09
                               625   236       278     59 83330251138108207 85  F10
                         391320217   241     56383102243253        15       16  F11
                      351 22   257   159131    314289104                        F12
                      349      305       302   527 30                           F13
                      404      366       281129444 33                           F14
                   295160      391       283332   265       12 59 42 21  3      F15
             101295511 51      531449623576       205263156 70           3  15  F16
                473141333426466795452585518224 79234285147                  16  F17
             242137           205436620257257297306311254362291214203170173159  F18
             356         215194290335193109                                     F19
             352      140275   423      13 90 28       41 74 66 65 43 11        F20
1692713111383990456426494178395190 51                                           F21
             222   126 17104150          37                                     F22
             242   156158109                                                    F23
             155 68144                                                          F24
 59          94119                                                              F25
```

Card Type 12 (continued)

```
                                                                               F26
            166                                                                S01
                                                                 5119 18       S02
                                                           7218196 52          S03
                                                       34104277 94114 10       S04
                                                    36125107248215100 29 15    S05
                             5  5                36 24133135116 74 80 11 26    S06
                    4  5 25176 89             33 48114195116166203190 98 19    S07
                   30 49 28142145 75157126153175 60125212200219249266182 32    S08
                   46121188266254157413386317162 75116209220255149168163 28    S09
                    1239304249175 94283192282165155173259228304169123109 11    S10
                    9360324231124 79204288430204138186395242323241113 31  6    S10
                  124215412322210121270312301 93 96104270179290197 82 48 30    011
                  189255328358176265293257298241230135114 62129114 95 57  4    S12
                222612963097285314254292255386263229234131240156103 21  9  7   S13
               106266413392331393273322305265253190295119 42 22  1 37  1  5    S14
             88305255255311473477364292273249198185 69 21 82 42 90 33 12       S15
         125476254338261412413512329324293264195127 43 39227121 45 53 27  5    S16
 47 64 991172315123454593478468642579290199186 75108173131180142 18 49 50 73   S17
    18      7 98293403549512572473226217229285243250242114190280244 71 10 99   S18
  9 25      2 30 70 322603478375259164116190236227236185160130155232143 66 77  S19
 25 30 17 12 59 63121155116 25245242191162318308241218183 77126149151 76 32    S20
139118107194182350268280247140204204 21173241212156 91 57  1  6  6  2          S21
239250249250264414328276212215  4131 58 91113 21  1  2           1  2          S22
137255738238266295251233 54 20 27157 50  4        1                 2          S23
 60155202223252221152 85 66 94 73  7  2        2                    2          S24
 35 12 34149146172135 43 28 17  1        4  2  1  2  2  1           2          S25
              60125 50                                                         S26
```

Card Type 13

```
                                                                 5             H01
                                                             10 11             H02
                                                       5 11  11 11             H03
                                                    5 11 11  11 11             H04
                29                               5 11 11 11  11                H05
                     5                        5 11 11 11 11  11 11 11          H06
              10 15 21 31 11               3 14 11 11 11 11  11 11 11 11       H07
              25 30 32 33 18 18 18 18 33 33 11 11 11 11 11  11 11 11 11        H08
              15 30 32 33 33 67 33 35 34 34 32 13 11 11 11  11 11 10           H09
               1 31 39 47 50 78 34 34 36 36 34 15 13 11 11  11 11  5           H10
               6 31 72 61 63 45 36 36 36 36 34 34 13 11 11  11 11  2           H11
               6 31 46 61 61 36 36 39 50 45 46 36 33 11 11  11  6              H12
              94 56 56 56 56 70 70 57 45 45 42 36 33 11 11   5                 H13
           10 56 56 56 56 56 70 70 57 50 50 35 35 20  4  4                     H14
           30 51 51 51 51 51 90 90 70 56 56 34 19 12 34  9  2  2  1            H15
        25 40 45 45 47 49 49110110 82 56 56 34  4 22 39 39 32 32  1            H16
     20 40 40 45 45 47 49 49110110 82 45 45 62 62 49 36 36  1  1  4 30         H17
30 30 30 35 39 33 33 33 35 37 37 60 60 53 45 45 62 62 49 36 36 31 31  4 30      H18
          5 24 39 33 33 35 37 37 60 60 53 40 40 49 43 43 38 38 31 31 32 30      H19
             5 15 23 33 36 39 39 48 48 44 35 35 37 37 39 41 41 30 30 20 10      H20
    1  1    15 15 19 34 38 42 42 36 36 35 35 35 37 37 39 41 41 30 15           H21
30 31 31 30 30 30 34 34 38 42 42 36  6 35 35 35 37 37 39 41 41 30 15           H22
30 31 31 35 39 39 53 53 48 33 23 31 31 30 25 15                                H23
30 31 31 35 39 39 53 53 48 13 13 31 16  5                                      H24
          3 36 36 42 42 40 37 27 10                                            H25
          1 32 32 31 31  1                                                     H26
                                                                1  3           N01
                                                             3 11 11           N02
```

Card Type 13 (continued)

```
                                                        5 11 11 11            N03
                                                     5 11 11 11 11            N04
                                                  5 11 11 11 11               N05
                                               5 11 11 11 11 11 11 11         N06
                   14 18 21 23 25 37 37 30 22 13 11 11 11 11 11 11 11 11      N07
                   10 18 21 23 23480 35 55 21 21 11 11 11 11 11 11 11 11      N08
                      19 24 29 63603 30 26 22 22 13 11 11 11 11 11 11  8      N09
                    5 21371 34 61141 25 24 23 23 19 11 11 11 11 11 11  5      N10
                    6 21 27 34 34 25 25 24 23 23 19 19 11 11 11 11 11  2      N11
                  584 29 25 22 22 24 24 24 92 23162 27 23 11 11 11  8         N12
                 6 29 29 25 22 22 24 24 24 23 23104 27 23 11 11  5            N13
                13 25 25 22 20 20 31 31 26 22 22 22 18  7                     N14
             10 19 21 21 20 19 20 38 38 29 21 21 19  5  3  9  2  1  1         N15
           4  9 18 20 20 20 19 19 37 37 29 21 21  9  1  6 15 19 18 18  9  8   N16
  8  8  8  9 19 19 19 20 20 21 21 21 21 20 19 19 22 22 21 20 20  1  1  1 10   N17
           1  6 10 10 10 11 12 12 12 12 11 10 10 13 13 12 11 11  9  9  1 10   N18
           1  3  7  9 18 19 19 19 19 19 18 18 18 19 19 20 20 20 17 17  9  9   N19
              4  4  4  8  9 10 10  9  9 18 16  8 16 18 18 14 13  9  9  7      N20
  8  8 12 14 12  8  8  8  9 10 10  9  1  9 10 10 16 19 16 14 13  9  9  9  8   N21
  8  9 13 18 15 15 17 15 12  7  4  8  8  8  8  3                              N22
  8  9  9 18 17 15 15 15 12  1  1  8  4  1                                    N23
     1  1  1 10 10 12 12 11  9  7  2                                          N24
              9  9  9  9  1  1                                                N25
                                                                              N26
                                                                15            L01
                                                             40 44            L02
                                                       20 44 44 44            L03
                                                    20 44 44 44 44            L04
                            10                   20 44 44 44 44               L05
                   11 26 72 95 26             20 44 44 44 44 44 44 44         L06
                   60 79 96111 63 91 91 91131 55 44 44 44 44 44 44 44 44      L07
                   40 79 96111111491156145 94 94 44 44 44 44 44 44 44 44      L08
                    3 78130182208576144122101101 86 51 44 44 44 44 44 40      L09
                   24 96433251271218131120108108 94 59 51 44 44 44 44 20      L10
                   54 96173251251131131152109108 94 94 51 44 44 44 44  5      L11
                  633233214193193245245197202150241137109 44 44 45 31         L12
                30233233214193193245245197150150196137109 44 44 23  1         L13
             10 90189189179175175333333277170170118119 68 19 19  1  1  1      L14
             71120145145150156156426426307189189 98 59 99108 38  7  7  4      L15
          41120121145145150156156426426307189189 98 19 69117117 86 86  4      L16
 79 79 79 99118118 90 90 98106106204204174143143212212158104104  6  6 21115   L17
          20 79118 90 90 98106106204204174143143212212158104104 85 85 21115   L18
     1  1 11 21 41 74 93105118118153153136122122159159137117117 82 82 90 97   L19
     2  2  2 41 41 57 96113129129103103102101101108106118128128 80 80 62 21   L20
 79 81 81 81 80 80 96 96113129129103 24102101101108108118129129 80 41  2  1   L21
 80 84 84105125125180180158116 76 81 81 80 70 30                              L22
 80 84 84105125125180180158 55 56 81 52 11                                    L23
     3  3  8108108123133101107 83 22  2  1                                    L24
           6 91 91 85 85  3                                                   L25
                                                                              L26
```

Card Type 14

```
NO2+HV       =NO+O           1  0  2 23  0 0.40          D 00
O+O2+M       =O3+M          23  0  3  0  0 0.14          D 07
O3+NO        =NO2+O2         3  2  1  0  0 0.4           D 00                                          3
NO2+O3       =NO3+O2         1  3 24  0  0 0.1           D-04                                          4
C2H3O3+O2 = C2H3O2+O3       25  0 21  3  0 0.2           D 02                                          5
NO3+NO       =2NO2          24  2  1  1  0 0.245         D 03                                          6
C3H6+OH = CH3CHO+CH3         4 15  6 17    0.1           D 04                                          7
NO+HO2       =NO2+OH         2 16  1 15  0 0.1           D 02                                          8
H+O2+M       =HO2+M         14  0 16  0  0 0.1           D 07                                          9
C2H3O + O2 = C2H3O3         20  0 25  0  0  .1           D 06                                         10
                                                                                                      11
NO2+OH       =HNO3           1 15  5  0  0 0.1           D 03                                         12
OH+O3        =HO2+O2        15  3 16  0  0 0.1           D 02                                         13
OH+CO        =H+CO2         15  8 14  0  0 0.3           D 01                                         14
CH3+O2+M     =CH3O2+M       17  0 19  0  0 0.14          D 07                                         15
CH3O2+NO     =CH3O+NO2      19  2 18  1  0 0.2           D 01                                         16
CH3O+O2+NO =CH3O2+NO2       18  2 19  1  0 0.1           D 02                                         17
C2H3O3+NO = C2H3O2+NO2       2 25  1 21  0  .25          D 01                                         18
C2H3O2+NO    =C2H3O+NO2     21  2 20  1  0 0.2           D 02                                         19
C2H4O2+NO =CH3CHO+NO2       22  2  6  1  0 0.1           D 03                                         20
CH3O+O2      =HCHO+HO2      18  0  7 16  0 0.2           D 03                                         21
C3H6+O       =CH3+C2H3O      4 23 17 20  0 0.350         D 02                                         22
C3H6+O3      =HCHO+C2H4O2    4  3  7 22  0 0.5           D-04                                         23
C3H6+O+O2    =HCHO+C2H4O2    4 23  7 22  0 0.175         D 02                                         24
C2H4O2+O2 = C2H3O3+OH       22  0 15 25  0  .3           D 03                                         25
C3H6+HO2     =CH3O+CH3CHO    4 16 18  6  0 0.1           D 01                                         26
C3H6+MEO2=CH3+MEO+C2H3O      4 19 17 18 20 0.1           D-01                                         27
C2H3O+M      =CH3+CO+M      20  0 17  8  0 0.1           D 02                                         28
CH3O+NO2     =CH3ONO2       18  1  9  0  0 0.1           D 01                                         29
C2H3O3+NO2 = C2H3O3NO2       1 25 10  0  0  .2           D 00                                         30
DUMHC+O      =CH3+C2H3O     12 23 17 20  0 0.70          D 01                                         31
HCHO + HV = H + H + CO       7  0 14 14  8 0.3           D-02                                         32
NO2 +NO3 +H2O = HNO3+ "      1 24  5  5  0 0.1           D 03                                         33
```

Card Type 15

```
.1       D 03            .5       D-01
```

Card Type 16

```
33.5         97.5       289.6       591.3      1170.4      1517.9
17.7         18.9        23.0        27.7        25.5        22.4
50.0        100.6       149.4       359.7       650.1      1527.1
20.0         23.0        22.7        23.9        28.5        22.7
```

Section VII
Glossary

A. COMMON REGIONS

1. KINCOM

A------Heading label
BB-----Numerical integration counter
C------Pollutant reaction rates
CC-----Plot data
D------Rates of reaction
DERY---Rates of change of species
INTR---Output list indicator
ITRAF--Execute traffic sources function indicator
KDIF---NDIF+2
LABEL--Species names
M------Page number of output
N------Temporary storage
NC-----No. of species
NDIF---No. of accumulating species
NEQ----No. of mechanism steps
NLL----No. of plot lines
NN-----No. of printouts
NNC----NC-NDIF
NNDIF--NDIF+1
PEAK1--Peak value of concentration 1
PEAK3--Peak value of concentration 3
PRMT---Parameter input list
RCT----Reaction list
STEP---Output list
TIM1---Half time of concentration 1
TIM2---Half time of concentration 2
TIM4---Half time of concentration 4
TIME1--Peak time of concentration 1
TIME3--Peak time of concentration 3
XPOS---X coordinate (miles)
YPOS---Y coordinate (miles)
YY-----Non-accumulating species
ZZ-----Chain yield

2. MYCOM

AIR----Meteorological data
AGRID1-Area source grid distribution of reactive hydrocarbons
AGRID2-Area source grid distribution of nitric oxide
AGRID4-Area source grid distribution of less reactive hydrocarbons
ARADIO-A.M. radiosonde curve
EMIT---Emission factors for vehicular sources
FGRID--Grid distribution of freeway traffic
ICLOUD-Type of clouds in sky
IDM----First time through METEOR module indicator
IDS----First time through SOURCE module indicator
IDU----First time through ULTRAV module indicator
IHT----Mixing height values input indicator
IPST---Pacific standard time indicator
NRAD---No. of radiosonde points
NSTA---No. of meteorological stations
POS----Stationary source position in meters
PRADIO-P.M. radiosonde curve
SGRID--Grid distribution of street traffic
TIME---Time of day
WPOS---Meteorological stations position and elevation
XDOT---X component of wind
XHITE--Array of input mixing height values
XMIN---Minimum mixing depth
YDOT---Y component of wind
ZENITH-12 hourly values of sun angle at Los Angeles

3. ALLCOM

ANS----Array of calculated meteorological values for the trajectory point
GOTIME-Simulation start time
GPOLL--Source inputs in gram-moles/minute
ISOUR--Execute source module indicator
POLL---Source inputs in pphm/minute
XDEPTH-Mixing depth
XDEPRV-Previous mixing depth

4. BARRR

IDB----First time through barrier check routine indicator

B. MAIN

1. Arrays

CSAVE--Holds correction terms and derivatives for DIFSUB
ERROR--Contains estimated one step error
IDMET--Pollutant station names
IDNUM--Meteorological station names
IP-----Temporary storage space for pivots
PW-----Temporary storage space
SAVE---Saves matrix Y
Y------Dependent variables and their scaled derivatives
YMAX---Maximum values of Y
YSAVE--Temporary storage for Y

2. Scalars

ATEMP--Temporary temperature
BAROM--Barometric pressure
DEWPT--Dew point
IN-----Another simulation run indicator
KFLAG--DIFSUB completion code indicator
MAXDER-Maximum derivative number
MF-----Method indicator for Gear
NDIM---Order of set of ordinary differential equations

C. SMGOUT

1. Arrays

Y------Dependent variables of differential equations (accumulating and non-accumulating species)

2. Scalars

H------Step size
HAL1---Half the current value of concentration 1
HAL2---Half the current value of concentration 2
HAL4---Half the current value of concentration 4
PREVY1-Previous value of concentration 1
PREVY2-Previous value of concentration 2
PREVY4-Previous value of concentration 4
PTIM1--Time when PREVY1 is saved
PTIM2--Time when PREVY2 is saved
PTIM4--Time when PREVY4 is saved
X------Time into simulation

D. DIFFUN

1. Arrays

DY-----First derivatives of accumulating species
Y------Set of accumulating and non-accumulating species
YSAVE--Temporary storage for Y

2. Scalars

STORE--Temporary rate of change of mixing depth
X------Time into simulation run
XPREV--Previous simulation time last step

E. METEOR

1. Arrays

DISINV-Sum of the square of the inverse distances from the air parcel location to the meteorological stations
DIST---Square of the distance from the air parcel point to a meteorological station
JBAR---Permissible station indicators
RADIO--Radiosonde curve in use
RSLOPE-Slopes of the line segments of RADIO
VAL1---Spatially interpolated meteorological values at first hour
VAL2---Spatially interpolated meteorological values at second hour

2. Scalars

HMIN---Minimum elevation point on the radiosonde curve
HOUR---Hour of the day
ITIME--Hour of the day minus 6
SLOPE--Adiabatic lapse rate
TIMEHR-Number of minutes into current hour
TMIN---Minimum temperature point on the radiosonde curve
X------X-coordinate position of the pollutant column
XPREV--Time previous cycle through routine
XTIME--Time into simulation run in minutes
XTIME1-Temporary storage of current time
XXDOT--X component of rate of change of wind
Y------Y-coordinate position of the pollutant column
YYDOT--Y-component of rate of change of wind

F. ULTRAV

1. Arrays

ABSOR--Absorption coefficients of NO_2 and N_2O_4
AIRMS--Air mass at various zenith angles
CLOUD--Average fractions of incident radiation transmitted by 7 cloud types
FLIST_-Dependent variable list corresponding to independent values in XLIST_
OZONE--Absorption coefficients of ozone in the ultraviolet region by wavelength, 3000A-4000A
SOLAR--Mean solar spectral irradiance outside the atmosphere for spectral bandwidths of 100A centered at wavelengths 3000A-4000A
VAPOR--Values of water vapor pressure for different temperatures
XLIST_-Independent variable interpolation list
XMOLE--Indices of refraction and molecular scattering coefficients for a homogeneous standard atmosphere at 3000A-4000A

2. Scalars

AIRMAS-Values of the air mass at various zenith angles
ALBEDO-Reflectively of the ground
ANGLE--Zenith angle of the sun
BETA---Value of air mass for given zenith angle
CANGLE-COS of zenith angle
C1-----Temporary storage
C2-----Temporary storage
DIRECT-Direct radiation from the sun in the smog layer
DUST---Dust content of the atmosphere; 1 near surface of urban areas, 0 in upper atmosphere
G------Parameter between 0 or 1 which is a function of the directional distribution of the scattered radiation and of the amount of multiple scattering
LAMDA--Wavelength in Angstroms
OZ3----Quantity of ozone in the atmosphere at standard temperature and pressure
PI-----3.14159
PRESS--Water vapor pressure
PZ-----Partial pressure of atmospheric water vapor
RATE---Specific ultraviolet absorpiton rate of NO_2
RATE1--Temporary storage
RATE2--Temporary storage
SCATOZ-Transmissivity with respect of ozone absorption
SCTMOL-Transmissivity relative to molecular scattering
SCTPAR-Transmissivity due to particle scattering
SKY----Radiation reflected from the sky into the smog layer

G. SOURCE

1. Arrays

DIST---Square of the distance from the air parcel position to the midpoint of the three closest grid areas
EMITWT-Temporary storage
EPOS---Midpoints of three closest grid areas
FCURVE-Temporal distribution curve of freeway traffic
IBOX---Number of grid containing the air parcel
SCURVE-Temporal distribution curve of street traffic
WEIGHT-Molecular weight of major pollutants

2. Scalars

AREA1--Reactive hydrocarbon emissions in grid area containing parcel (kg./hr.)
AREA2--NO emissions in grid area containing parcel (kg./hr.)
AREA4--Less reactive hydrocarbon emission in grid area containing parcel (kg./hr.)
AX-----Value of diurnal area source usage curve at any time during the day
DISINV-Sum of the square of the inverse distance from the air parcel location to the midpoint of an adjoining grid square
FACTOR-Conversion factor inversely proportional to mixing depth
FWY----Daily freeway mileage in grid square containing air parcel
FX-----Value of diurnal curve for freeway traffic at any time during the day
GMIN---Minutes into current hour of the day
IHR----Current hour of the day
IPT----Grid square quadrant indicator
IXM----X-coordinate of midpoint of grid square containing air parcel
IYM----Y-coordinate of midpoint of grid square containing air parcel
STREET-Daily street traffic mileage in grid square containing air parcel
SX-----Value of diurnal curve for street traffic at any time during the day
X------X-coordinate of air parcel location
Y------Y-coordinate of air parcel location

Section VIII

Program Listing of Reactive Pollutant Environmental Simulation Model (REM)

```
                                   OS/360  FORTRAN H

COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=55,SIZE=0000K,
                   SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
C     REACTIVE ENVIRONMENTAL MODEL       VERSION CB
C
      DIMENSION SAVE(13,40),CSAVE(40,3),YMAX(40),ERROR(40),PW(1600),
     1          IP(40),Y(13,40),YSAVE(40),IDNUM(32),IDMET(32),IR(50,5),
     2          DAIR(12,32,2),RSGRID(650),RFGRID(650),RGRID1(650),
     3          RGRID2(650),RGRID4(650)
      DOUBLE PRECISION C,D,Y,YY,ZZ,DERY,SAVE,CSAVE,YMAX,ERROR,YSAVE,
     1     POLL,PRMT,BB,Z
      REAL*8 LABEL,BLANK/'        '/,RCT
C
C
C     KINCOM---KINCOM---KINCOM---KINCOM---KINCOM
C
C     A-----HEADING LABEL
C     BB----SAVE PLOT DATA COUNTER
C     C-----POLLUTANT REACTION RATES
C     CC----PLOT DATA
C     D-----RATES OF REACTION
C     DERY--RATES OF CHANGE OF SPECIES
C     IDISP--TYPE OF DISPERSION CURVES
C     INTR--OUTPUT LIST INDICATOR
C     ISOUR-SOURCE EMISSIONS MODULE INDICATOR
C     ITRAF-TRAFFIC EMISSIONS MODULE INDICATOR
C     LABEL-SPECIES NAMES
C     N-----NO. OF COLUMNS FOR NUM. INT.
C     NC----NO. OF SPECIES
C     NDIF--NO. OF ACCUMULATING SPECIES
C     NEQ---NO. OF MECHANISM STEPS
C     NLL---NO. OF PLOT LINES
C     NN----NO. OF PRINTOUTS
C     NNC---NC-NDIF
C     NNDIF-NDIF+1
C     PEAK1-PEAK VALUE OF CONCENTRATION 1
C     PEAK3-PEAK VALUE OF CONCENTRATION 3
C     PRMT--PARAMETER INPUT LIST
C     RCT---REACTION LIST
C     STEP--OUTPUT LIST
C     TIM1--HALF TIME OF CONCENTRATION 1
C     TIM2--HALF TIME OF CONCENTRATION 2
C     TIM4--HALF TIME OF CONCENTRATION 4
C     TIME1-PEAK TIME OF CONCENTRATION 1
C     TIME3-PEAK TIME OF CONCENTRATION 3
C     XPOS--X COORDINATE (MILES)
C     YPOS--Y COORDINATE (MILES)
C     YY----NON-ACCUMULATING SPECIES
C     ZZ----CHAIN YIELD
C
C     NDIM--NO. OF ACCUMULATING SPECIES + 2
C     Y-----CONCENTRATIONS OF SPECIES
C
      COMMON /KINCOM/ ZZ(4),YY(40),LABEL(40),D(50),RCT(50,3),PRMT(8),
     1      DERY(40),C(50),BB,Z(2),N,NC,NEQ,NDIF,KDIF,M,NN,INTR,NNC,
     2      NNDIF,IUV,IM,IS,ITRAF,NLL,CC(16,100),A(80),STEP(15),TIM1,
     3      TIM2,TIM4,PEAK1,TIME1,PEAK3,TIME2,XPOS,YPOS
C
C
C
C
C
C     MYCOM---MYCOM---MYCOM---MYCOM---MYCOM---MYCOM
C
C     AGRID1-AREA SOURCE PROPYLENE EMISSIONS
C     AGRID1-AREA SOURCE NO        EMISSIONS
C     AGRID1-AREA SOURCE DUMHC     EMISSIONS
C     AIR----METEOROLOGICAL DATA
C     EMIT---TRAFFIC MODULE EMISSION RATES
C     ICLOUD-TYPE OF CLOUDS IN SKY
C     IDM----FIRST TIME THROUGH METEOR MODULE INDICATOR
C     IDS----FIRST TIME THROUGH SOURCE MODULE INDICATOR
C     IDU----FIRST TIME THROUGH ULTRAV MODULE INDICATOR
C     IHT----MIXING HEIGHT VALUES INPUT INDICATOR
C     IPST---PACIFIC STANDARD TIME INDICATOR
C     NRAD---NO. OF RADIOSONDE POINTS
C     NSTA---NO. OF METEOROLOGICAL STATIONS
C     NSTACK-NO. OF STATIONARY SOURCES
C     TIME---TIME OF DAY
C     WPOS---METEOROLOGICAL STATIONS POSITION AND ELEVATION
C     XDOT---X COMPONENT OF WIND
C     XHITE--ARRAY OF INPUT MIXING HEIGHT VALUES
C     XHT----MIXING HEIGHT
C     YDOT---Y COMPONENT OF WIND
C     ZENITH-12 HOURLY VALUES OF SUN ANGLE AT LOS ANGELES
C
      COMMON /MYCOM/ TIME,ICLOUD,IDM,IDU,IDD,IDS,IPST,NSTA,NSTACK,NRAD,
     1         AIR(12,32,6),WPOS(32,3),POS(32,3),SPOS(32,3),HS(12),
     2         DS(12),VS(12),TS(12),QS(12),SBAROM,STEMP,XDOT,YDOT,
     3         ARADIO(15,2),PRADIO(15,2),ZENITH(12,2),SGRID(650),
     4         FGRID(650),AGRID1(650),AGRID2(650),AGRID4(650),EMIT(10),
     5         XHITE(12),IHT,XMIN
C
      COMMON  /BARRR/ IDB
C     IDB----FIRST TIME THROUGH BARRIER CHECK INDICATOR
C
C
C     ALLCOM---ALLCOM---ALLCOM---ALLCOM---ALLCOM---ALLCOM
C
C     ANS----ARRAY OF CALCULATED METEOR. VALUES FOR THE TRAJ. PT.
C     GOTIME-SIMULATION START TIME
C     ISOUR--SOURCES MODULE INDICATOR
C     POLL---ARRAY OF CALCULATED TRAFFIC AND AREA SOURCES
C     XDEPTH-MIXING DEPTH AT TRAJECTORY POINT
C     XDEPRV-LAST CALCULATED MIXING DEPTH
C
      COMMON /ALLCOM/ POLL(4,3),GPOLL(4,3),ANS(8),GOTIME,XDEPTH,ISOUR,
     1                 XDEPRV
C
C
C
      EXTERNAL DIFFUN
      RH(ATEMP,DEWPT) = 10.**(7.5*(DEWPT/(DEWPT+237.3)
     1                 -ATEMP/(ATEMP+237.3)))
C
C     INITIALIZATION
C
C
C     INPUT HEADING INFORMATION
C
      IN = 0
    1 READ (5,1000,END=900) A
      JSTART = 0
      DO 10  I=1,40
      DO 5  J=1,13
    5 Y(J,I) = 0.D0
      YMAX(I) = 1.0D0
      YSAVE(I) = 0.D0
      LABEL(I) = BLANK
      D(I) = 0.0D0
   10 DERY(I) = 0.0D0
      DO 20  I=1,4
   20 ZZ(I) = 0.0D0
      N = 0
      M = 1
      NN = 1
      BB = 1.0E08
      IDB = 0
      IDD = 0
      IDM = 0
      IDS = 0
      IDU = 0
      IPST = 0
      IUV = 0
      IM = 0
      IS = 0
      DO 30  I=1,4
      DO 30  J=1,3
      SPOLL(I,J) = 0.
   30 POLL(I,J) = 0.D0
C
      BAROM = 1013.
      COVER = 0.
C
C     INPUT START POSITION, START TIME, MINIMUM XDEPTH
C     INPUT LENGTH OF SIMULATION, HMIN, HMAX, INITIAL STEP SIZE, ERROR
C           CRITERION, PLOT VALUE INDEX
C
      READ (5,1001) XPOS,YPOS,GOTIME,XMIN
      READ (5,1006) (PRMT(I),I=2,7)
      IF (PRMT(7))  70,70,75
   70 PRMT(7) = 2.D0*PRMT(2)
   75 PRMT(1) = 0.
      PRMT(8) = PRMT(1)
C
C     INPUT NO. OF ACCUMULATING SPECIES, TOTAL NO. OF SPECIES, NO. OF
C           MECHANISM STEPS, PLOT LINE PARAMETER, NO. OF METEOROLOGICAL
C           STATIONS, NUMERICAL INTEGRATION METHOD, NO. OF DERIVS. CLOUD
C           TYPES, NO. OF RADIOSONDE POINTS, TRAFFIC MODULE, SOURCE
C           MODULE, MIXING HEIGHT, SAME DAY FOR NEXT RUN, AND PACIFIC
C           STANDARD TIME INDICATORS
C
      READ (5,1002) NDIM,NC,NEQ,NLL,NSTA,MF,MAXDER,ICLOUD,NPAD,ITRAF,
     1  ISOUR,IHT,IN,IPST
C
C     INPUT OUTPUT INDICATOR AND LIST OF APPROXIMATE OUTPUT TIMES
C
      READ (5,1003) INTR,STEP
      NDIF = NDIM
      NDIM = NDIM+2
      KDIF = NDIM
      NNDIF = NDIF+1
C
C     INPUT MIXING HEIGHT
C
      IF (IHT .NE. 1)   GO TO 80
      READ (5,1020)  XHITE
C
C     INPUT SPECIES LIST AND INITIAL CONCENTRATIONS
C           CONCENTRATIONS ARE IN PPHM EXCEPT FOR CO IN PPM
C
   80 READ (5,1004)  (LABEL(I),Y(1,I),I=1,NC)
C
C     SAVE NON-ACCUMULATING SPECIES
C
      DO 85  I=NNDIF,40
      YY(I) = Y(1,I)
   85 Y(1,I) = 0.D0
C
C
C
C
C
C
C     CHECK FOR SECOND RUN
C
      IF (IN .EQ. 1)   GO TO 300
C
C     INPUT SUN ANGLE AT LOS ANGELES
C
      READ (5,1032) ((ZENITH(I,J),J=1,2),I=1,12)
C
C     INPUT METEOROLOGICAL DATA.
```

```
C
      DO 100  J=1,NSTA
      READ (5,1005)  IDNUM(J),((AIR(I,J,K),K=1,4),I=1,4)
      READ (5,1005)  IDNUM(J),((AIR(I,J,K),K=1,4),I=5,8)
  100 READ (5,1005)  IDNUM(J),((AIR(I,J,K),K=1,4),I=9,12)
C
C     INPUT METEOROLOGICAL STATION DATA
C
      WRITE (6,1013)
      READ (5,1014) (IDMET(I),(WPOS(I,J),J=1,3),I=1,NSTA)
C
C     CONVERT DATA TO METRIC UNITS
C
      DO 120  I=1,NSTA
      WPOS(I,3) = WPOS(I,3)*.3048
      DO 120  J=1,12
      IF (AIR(J,I,3) .EQ. 0)  GO TO 105
      AIR(J,I,3) = (AIR(J,I,3)-32.)*.55555
  105 IF (AIR(J,I,4) .EQ. 0)  GO TO 120
  107 AIR(J,I,4) = (AIR(J,I,4)-32.)*.55555
  120 CONTINUE
C
C     DETERMINE RELATIVE HUMIDITY.
C
  130 DO 150  I=1,12
      DO 150  J=1,NSTA
      IF (AIR(I,J,3) .NE. 0.)  GO TO 140
      AIR(I,J,4) = 0.
      GO TO 150
  140 IF (AIR(I,J,4) .EQ. 0.)  GO TO 150
      ATEMP = AIR(I,J,3)
      DEWPT = AIR(I,J,4)
      AIR(I,J,4) = RH(ATEMP,DEWPT)
  150 CONTINUE
C
C     OUTPUT METEOROLOGICAL DATA
C
  160 WRITE (6,1015) (IDMET(I),(WPOS(I,J),J=1,3),I=1,NSTA)
      IF (IHT .NE. 1)    GO TO 165
      WRITE (6,1021)  XHITE
  165 KOUT = 0
      WRITE (6,1007)
      DO 180  I=1,12
      IH = (I+6)*100
      DO 180  J=1,NSTA
      IF (KOUT .LE. 50)   GO TO 170
      KOUT = 0
      WRITE (6,1007)
      GO TO 180
  170 KOUT = KOUT+1
  180 WRITE (6,1008)  IDNUM(J),IH,(AIR(I,J,K),K=1,4)
C
C     SAVE  WIND DATA
```

```
C
      DO 200  J=1,12
      DO 200  I=1,NSTA
      DAIR(J,I,1) = AIR(J,I,2)
  200 DAIR(J,I,2) = AIR(J,I,1)
C
C     CONVERT WIND DATA TO RADIANS
C
      DO 230  J=1,12
      DO 230  I=1,NSTA
      AIR(J,I,1) = -DAIR(J,I,1)*SIN(DAIR(J,I,2)*3.14159/180.)
  230 AIR(J,I,2) = -DAIR(J,I,1)*COS(DAIR(J,I,2)*3.14159/180.)
C
C     INPUT TRAFFIC DATA.
C
      IF (ITRAF .EQ. 0)  GO TO 240
      READ (5,1027) EMIT
      READ (5,1009) FGRID,SGRID
      DO 232  I=25,650,25
      DO 232  J=1,25
      JJJ = J-I+650
      III = J+I-25
      RFGRID(JJJ) = FGRID(III)
  232 RSGRID(JJJ) = SGRID(III)
      WRITE (6,1029) RFGRID
      WRITE (6,1030) RSGRID
      DO 235  I=1,650
      FGRID(I) = FGRID(I)*1000.
  235 SGRID(I) = SGRID(I)*1000.
C
C     INPUT AREA SOURCES DATA
C
  240 IF (ISOUR .EQ. 0)  GO TO 260
      READ (5,1009) AGRID1,AGRID2,AGRID4
      DO 233  I=25,650,25
      DO 233  J=1,25
      JJJ = J-I+650
      III = J+I-25
      RGRID1(JJJ) = AGRID1(III)
      RGRID2(JJJ) = AGRID2(III)
  233 RGRID4(JJJ) = AGRID4(III)
      WRITE (6,1034) RGRID1
      WRITE (6,1035) RGRID2
      WRITE (6,1036) RGRID4
      DO 250  I=1,650
      AGRID1(I) = AGRID1(I)*1000.
      AGRID2(I) = AGRID2(I)*1000.
  250 AGRID4(I) = AGRID4(I)*1000.
      WRITE (6,1028)    (EMIT(I),I=1,4)
C
C     INPUT REACTION DATA
C
  260 READ (5,1011)  ((RCT(I,J),J=1,3),(IR(I,K),K=1,5),C(I),I=1,NEQ)
```

```
      READ (5,1038) Z
C
C     INPUT AM AND PM RADIOSONDE CURVES
C
      IF (IHT .EQ. 1)    GO TO 280
      READ (5,1022) (ARADIO(I,1),I=1,NRAD)
      READ (5,1022) (ARADIO(I,2),I=1,NRAD)
      READ (5,1022) (PRADIO(I,1),I=1,NRAD)
      READ (5,1022) (PRADIO(I,2),I=1,NRAD)
      WRITE (6,1023) (ARADIO(I,1),ARADIO(I,2),I=1,NRAD)
      WRITE (6,1024) (PRADIO(I,1),PRADIO(I,2),I=1,NRAD)
  280 WRITE (6,1033) ((ZENITH(I,J),J=1,2),I=1,12)
      IN = 1
  300 WRITE (6,1025) (PRMT(I),I=2,7),GOTIME,MF,MAXDER,A
      WRITE (6,1010)
      DO 320  I=1,NEQ
  320 WRITE (6,1012) I,(RCT(I,J),J=1,3),C(I),(IR(I,K),K=1,5)
      WRITE (6,1039) Z
      WRITE (6,1031)
      WRITE (6,1037) (I,LABEL(I),Y(1,I),DERY(I),I=1,NC)
C
C     SET UP POSITION FOR INTEGRATION
C
      Y(1,NDIF+1) = XPOS
      Y(1,NDIF+2) = YPOS
  400 CALL DIFSUB (NDIM,PRMT(1),Y,SAVE,CSAVE,PRMT(5),PRMT(3),PRMT(4),
     1               PRMT(6),MF,YMAX,ERROR,KFLAG,JSTART,MAXDER,PW,IP)
      IF (KFLAG .NE. 1)  GO TO 900
      DO 420  J=1,NC
  420 YSAVE(J) = Y(1,J)
      CALL SMGOUT (PRMT(1),YSAVE,PRMT(5))
      JSTART = 1
      IF (PRMT(1) .LT. PRMT(2))  GO TO 400
      IF (NEQ .EQ. 1)    GO TO 1
      CALL SMGPLT
      GO TO 1
  900 WRITE (6,1026) KFLAG
      STOP
 1000 FORMAT(20A4)
 1001 FORMAT(4F10.3)
 1002 FORMAT(14I5)
 1003 FORMAT(I2,3X,15F5.2)
 1004 FORMAT(4(A8,D12.8))
 1005 FORMAT(A3,3X,4(F3.0,F3.1,F3.0,F2.0,6X),6X)
 1006 FORMAT(6F10.3)
 1007 FORMAT(1H1,'STATION',5X,'DATA',6X,'WIND',6X,'WIND',16X,'REL.',
     1          /'  ','NUMBER',6X,'HOUR',6X,'DIR.',5X,'SPEED',5X,'TEMP',
     25X,'HUM.',                            /' ',22X,'(DEG)',5X,'(MPH)',4X,
     3'(CENT)',             //)
 1008 FORMAT(' ',A7,6X,I4,6F10.3)
 1009 FORMAT(25F3.0)
 1010 FORMAT('OK-VALUES FOR REACTIONS'//)
 1011 FORMAT (3A8,5I3,D15.8,26X)
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1012 FORMAT(' ',I4,5X,3A8,D20.8,5X,5I3)
1013 FORMAT(1H1,30X,'METEOROLOGICAL STATIONS',/1H0,21X,'X-COORD',11X,
    1'Y-COORD',10X,'ELEVATION',/' ',3X,'STATION',11X,'(MILES)',11X,
    2'(MILES)',11X,'(METERS)'/)
1014 FORMAT(4(A3,2F5.2,F7.2))
1015 FORMAT(' ',A10,2F18.3,F19.3)
1020 FORMAT(12F6.0)
1021 FORMAT(//////' INPUT MIXING HEIGHTS---0700 HOURS TO 1800 HOURS',//
    110X,12F9.1)
1022 FORMAT(8F10.1)
1023 FORMAT(1H1,20X,'AM RADIOSONDE CURVE',///1H ,23X,'HEIGHT',6X,'TEMP'
    1,/1H ,21X,'(METERS)    (CENT.)',//(1H ,19X,2F10.1))
1024 FORMAT(1H0,20X,'PM RADIOSONDE CURVE',///1H ,23X,'HEIGHT',6X,'TEMP'
    1,/1H ,21X,'(METERS)    (CENT.)',//(1H ,19X,2F10.1))
1025 FORMAT('1',D10.4,' MIN SIMULATION',4X,'HMIN=',D10.4,4X,'HMAX=',
    1 D10.4,4X,'INITIAL H=',D10.4/30X,'ERROR CRITERIA=',D10.4,13X,
    2 'BB=',D10.4//' START TIME IS',F8.4,' HOURS',21X,'MF=',I2,14X,
    3 'MAXDER=',I3//4(' ',20A4,/))
1026 FORMAT(//////' KFLAG= ',I3)
1027 FORMAT(10F5.2)
1028 FORMAT(//////' TRAFFIC EMISSION RATES',//'  PROPYLENE=',F5.2,10X,
    1'NO=',F5.2,10X,'CO=',F5.2,10X,'DUMHC=',F5.2)
1029 FORMAT(1H1,'GRID DISTRIBUTION OF FREEWAY TRAFFIC IN THOUSANDS OF V
    1EHICLE MILES PER DAY',//(25F5.0))
1030 FORMAT(1H1,'GRID DISTRIBUTION OF STREET TRAFFIC IN THOUSANDS OF VE
    1HICLE MILES PER DAY'//(25F5.0))
1031 FORMAT(1H1,'STARTING VALUES'///,8X,'  COMPOUND   CONCN PPHM    CHA
    1NGE, PPHM/MIN'/)
1032 FORMAT(8(2F5.1))
1033 FORMAT('0',20X,'ANGLE OF THE SUN AT LOS ANGELES',//'0',25X,'HOUR',
    1 5X,'ANGLE',///(1H ,19X,2F10.1))
1034 FORMAT    (1H1,'GRID DISTRIBUTION OF REACTIVE HYDROCARBONS (PROPYL
    1ENE) IN KILOGRAMS PER HOUR',//(25F5.0))
1035 FORMAT(1H1,'GRID DISTRIBUTION OF NO IN KILOGRAMS PER HOUR',//(25F5
    1.0))
1036 FORMAT(1H1,'GRID DISTRIBUTION OF LESS REACTIVE HYDROCARBONS (DUMHC
    1) IN KILOGRAMS PER HOUR',//(25F5.0))
1037 FORMAT(' ',5X,I3,1X,A8,2D16.7)
1038 FORMAT (2D20.8)
1039 FORMAT (//////10X,'Z(1)=',D10.4,10X,'Z(2)=',D10.4)
     END
```

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                                   OS/360  FORTRAN H

COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=55,SIZE=0000K,
                  SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
      SUBROUTINE DIFSUB(N,T,Y,SAVE,CSAVE,H,HMIN,HMAX,EPS,MF,YMAX,        00379000
     1             ERROR,KFLAG,JSTART,MAXDER,PW,IP)                       00380000
      IMPLICIT REAL*8 (A-H,O-Z)                                           00381000
C***********************************************************************00382000
C*                                                                     *00383000
C* THIS SUBROUTINE INTEGRATES A SET OF N ORDINARY DIFFERENTIAL FIRST   *00384000
C* ORDER EQUATIONS OVER ONE STEP OF LENGTH H AT EACH CALL.  H CAN BE   *00385000
C* SPECIFIED BY THE USER FOR EACH STEP, BUT IT MAY BE INCREASED OR     *00386000
C* DECREASED BY DIFSUB WITHIN THE RANGE HMIN TO HMAX IN ORDER TO       *00387000
C* ACHIEVE AS LARGE A STEP AS POSSIBLE WHILE NOT COMMITTING A SINGLE   *00388000
C* STEP ERROR WHICH IS LARGER THAN EPS IN THE L-2 NORM, WHERE EACH     *00389000
C* COMPONENT OF THE ERROR IS DIVIDED BY THE COMPONENTS OF YMAX.        *00390000
C*                                                                     *00391000
C* THE PROGRAM REQUIRES FOUR SUBROUTINES NAMED                         *00392000
C*    DIFFUN(T,Y,DY)                                                   *00393000
C*    DECOMP(N,M,PW,IP)                                                *00394000
C*    SOLVE(N,M,PW,CSAVE(1,1),IP)                                      *00395000
C*    PEDERV(T,Y,PW,M)                                                 *00396000
C* THE FIRST, DIFFUN, EVALUATES THE DERIVATIVES OF THE DEPENDENT       *00397000
C* VARIABLES STORED IN Y(1,I) FOR I = 1 TO N, AND STORES THE           *00398000
C* DERIVATIVES IN THE ARRAY DY.  THE NEXT TWO ARE CALLED ONLY IF THE   *00399000
C* METHOD FLAG MF IS SET TO 1 OR 2 FOR STIFF METHODS.  DECOMP IS A     *00400000
C* STANDARD LU DECOMPOSITION WITH PIVOTING THAT DECOMPOSES THE MATRIX  *00401000
C* PW, LEAVING THE PIVOTS IN THE INTEGER ARRAY IP.  M IS THE DECLARED  *00402000
C* SIZE OF PW.  IP(N) IS SET TO 0 IF PW IS SINGULAR.  SOLVE PERFORMS   *00403000
C* BACK SUBSTITUTION ON THE CONTENTS OF CSAVE(I,1), LEAVING THE        *00404000
C* RESULTS THERE.  THE MATRIX IN BOTH SHOULD BE SINGLE PRECISION,      *00405000
C* WHILE ALL FLOATING POINT VECTORS SHOULD BE DOUBLE PRECISION.        *00406000
C* PEDERV IS USED ONLY IF MF IS 1, AND COMPUTES THE PARTIAL            *00407000
C* DERIVATIVES OF THE DIFFERENTIAL EQUATIONS AS DESCRIBED UNDER THE    *00408000
C* MF PARAMETER.                                                       *00409000
C*                                                                     *00410000
C* THE PROGRAM USES DOUBLE PRECISION ARITHMETIC FOR ALL FLOATING       *00411000
C* POINT VARIABLES EXCEPT THOSE STARTING WITH P.  THE FORMER ARE       *00412000
C* SINGLE PRECISION TO SAVE TIME AND SPACE.                            *00413000
C*                                                                     *00414000
C* THE TEMPORARY STORAGE SPACE IS PROVIDED BY THE CALLER IN THE        *00415000
C* INTEGER ARRAY IP, THE SINGLE PRECISION ARRAY PW, AND THE DOUBLE     *00416000
C* PRECISION ARRAYS SAVE AND CSAVE.  THE ARRAY PW IS USED ONLY TO HOLD *00417000
C* THE MATRIX OF THE SAME NAME, AND SAVE IS USED TO SAVE THE VALUES    *00418000
C* OF Y IN CASE A STEP HAS TO BE REPEATED, BUT CSAVE IS USED TO HOLD   *00419000
C* SEVERAL ARRAYS.  THE REGIONS USED ARE                               *00420000
C*    CSAVE(I,1)    IS USED MAINLY TO HOLD THE CORRECTION TERMS IN THE *00421000
C*                  CORRECTOR LOOP, AND HOLDS THE DERIVATIVES DURING   *00422000
C*                  JACOBIAN EVALUATIONS.                              *00423000
C*    CSAVE(I,2)    IS USED TO SAVE THE VALUES OF THE SUMS OF ALL OF THE*00424000
C*                  CORRECTION TERMS IN THE PREVIOUS STEP AFTER THEY   *00425000
C*                  HAVE BEEN ACCUMULATED IN THE ARRAY ERROR IN THE    *00426000
C*                  CURRENT STEP.  THIS ENABLES THE BACKWARDS DIFFERENCE*00427000
C*                  OF ERROR TO BE FORMED.  IT IS USED TO ESTIMATE THE *00428000
C*                  STEP SIZE FOR ONE ORDER HIGHER THAN CURRENT.       *00429000
C*
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C*    CSAVE(I,3)    IS USED TO STORE THE DERIVATIVES WHEN THEY ARE
C*                  COMPUTED BY DIFFUN.
C*
C* THE PARAMETERS TO THE SUBROUTINE DIFSUB HAVE
C* THE FOLLOWING MEANINGS..
C*
C*   N        THE NUMBER OF FIRST ORDER DIFFERENTIAL EQUATIONS.  N
C*              MAY BE DECREASED ON LATER CALLS IF THE NUMBER OF
C*              ACTIVE EQUATIONS REDUCES, BUT IT MUST NOT BE
C*              INCREASED WITHOUT CALLING WITH JSTART = 0.
C*   T        THE INDEPENDENT VARIABLE.
C*   Y        A 13 BY N ARRAY CONTAINING THE DEPENDENT VARIABLES AND
C*              THEIR SCALED DERIVATIVES.  Y(J+1,I) CONTAINS
C*              THE J-TH DERIVATIVE OF Y(I) SCALED BY
C*              H**J/FACTORIAL(J) WHERE H IS THE CURRENT
C*              STEP SIZE. ONLY Y(1,I) NEED BE PROVIDED BY
C*              THE CALLING PROGRAM ON THE FIRST ENTRY.
C*                IF IT IS DESIRED TO INTERPOLATE TO NON MESH POINTS
C*              THESE VALUES CAN BE USED.  IF THE CURRENT STEP SIZE
C*              IS H AND THE VALUE AT T + E IS NEEDED, FORM
C*              S = E/H, AND THEN COMPUTE
C*                               NQ
C*                Y(I)(T+E) =   SUM   Y(J+1,I)*S**J
C*                               J=0
C*   SAVE     A BLOCK OF AT LEAST 13*N FLOATING POINT LOCATIONS.
C*   CSAVE    N*3 FLOATING POINT LOCATIONS USED BY THE SUBROUTINES.
C*   H        THE STEP SIZE TO BE ATTEMPTED ON THE NEXT STEP
C*              H MAY BE ADJUSTED UP OR DOWN BY THE PROGRAM
C*              IN ORDER TO ACHEIVE AN ECONOMICAL INTEGRATION.
C*              HOWEVER, IF THE H PROVIDED BY THE USER DOES
C*              NOT CAUSE A LARGER ERROR THAN REQUESTED, IT
C*              WILL BE USED.  TO SAVE COMPUTER TIME, THE USER IS
C*              ADVISED TO USE A FAIRLY SMALL STEP FOR THE FIRST
C*              CALL.  IT WILL BE AUTOMATICALLY INCREASED LATER.
C*   HMIN     THE MINIMUM STEP SIZE THAT WILL BE USED FOR THE
C*              INTEGRATION.  NOTE THAT ON STARTING THIS MUST BE
C*              MUCH SMALLER THAN THE AVERAGE H EXPECTED SINCE
C*              A FIRST ORDER METHOD IS USED INITIALLY.
C*   HMAX     THE MAXIMUM SIZE TO WHICH THE STEP WILL BE INCREASED
C*   EPS      THE ERROR TEST CONSTANT.  SINGLE STEP ERROR ESTIMATES
C*              DIVIDED BY  YMAX(I)  MUST BE LESS THAN THIS
C*              IN THE EUCLIDEAN NORM. THE STEP AND/OR ORDER IS
C*              ADJUSTED TO ACHEIVE THIS.
C*   MF       THE METHOD INDICATOR. THE FOLLOWING ARE ALLOWED..
C*                      0    AN ADAMS PREDICTOR CORRECTOR IS USED.
C*                      1    A MULTI-STEP METHOD SUITABLE FOR STIFF
C*                              SYSTEMS IS USED. IT WILL ALSO WORK FOR
C*                              NON STIFF SYSTEMS.  HOWEVER THE USER
C*                              MUST PROVIDE A SUBROUTINE PEDERV WHICH
C*                              EVALUATES THE PARTIAL DERIVATIVES OF
C*                              THE DIFFERENTIAL EQUATIONS WITH RESPECT
C*                              TO THE Y'S.   THIS IS DONE BY CALL
C*                              PEDERV(T,Y,PW,M). PW IS AN N BY N ARRAY
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C*                           WHICH MUST BE SET TO THE PARTIAL OF       *00483000
C*                           THE I-TH EQUATION WITH RESPECT            *00484000
C*                           TO THE J DEPENDENT VARIABLE IN PW(I,J).   *00485000
C*                           PW IS ACTUALLY STORED IN AN M BY M        *00486000
C*                           ARRAY WHERE M IS THE VALUE OF N USED ON   *00487000
C*                           THE FIRST CALL TO THIS PROGRAM.           *00488000
C*                     2   THE SAME AS CASE 1, EXCEPT THAT THIS        *00489000
C*                           SUBROUTINE COMPUTES THE PARTIAL           *00490000
C*                           DERIVATIVES BY NUMERICAL DIFFERENCING     *00491000
C*                           OF THE DERIVATIVES. HENCE PEDERV IS       *00492000
C*                           NOT CALLED.                               *00493000
C*    YMAX    AN ARRAY OF  N LOCATIONS WHICH CONTAINS THE MAXIMUM      *00494000
C*              OF EACH Y SEEN SO FAR.  IT SHOULD NORMALLY BE SET TO   *00495000
C*              1 IN EACH COMPONENT BEFORE THE FIRST ENTRY. (SEE THE   *00496000
C*              DESCRIPTION OF EPS.)                                   *00497000
C*    ERROR   AN ARRAY OF  N ELEMENTS WHICH CONTAINS THE ESTIMATED     *00498000
C*              ONE STEP ERROR IN EACH COMPONENT.                      *00499000
C*    KFLAG   A COMPLETION CODE WITH THE FOLLOWING MEANINGS..          *00500000
C*                     +1  THE STEP WAS SUCCESFUL.                     *00501000
C*                     -1  THE STEP WAS TAKEN WITH H = HMIN, BUT THE   *00502000
C*                           REQUESTED ERROR WAS NOT ACHIEVED.         *00503000
C*                     -2  THE MAXIMUM ORDER SPECIFIED WAS FOUND TO    *00504000
C*                           BE TOO LARGE.                             *00505000
C*                     -3  CORRECTOR CONVERGENCE COULD NOT BE          *00506000
C*                           ACHIEVED FOR H .GT. HMIN.                 *00507000
C*                     -4  THE REQUESTED ERROR IS SMALLER THAN CAN     *00508000
C*                           BE HANDLED FOR THIS PROBLEM.              *00509000
C*    JSTART  AN INPUT INDICATOR WITH THE FOLLOWING MEANINGS..         *00510000
C*                     -1  REPEAT THE LAST STEP WITH A NEW H           *00511000
C*                      0  PERFORM THE FIRST STEP.  THE FIRST STEP     *00512000
C*                           MUST BE DONE WITH THIS VALUE OF JSTART    *00513000
C*                           SO THAT THE SUBROUTINE CAN INITIALIZE     *00514000
C*                           ITSELF.                                   *00515000
C*                     +1  TAKE A NEW STEP CONTINUING FROM THE LAST.   *00516000
C*              JSTART IS SET TO NQ, THE CURRENT ORDER OF THE METHOD   *00517000
C*              AT EXIT.  NQ IS ALSO THE ORDER OF THE MAXIMUM          *00518000
C*              DERIVATIVE AVAILABLE.                                  *00519000
C*    MAXDER  THE MAXIMUM DERIVATIVE THAT SHOULD BE USED IN THE        *00520000
C*              METHOD.  SINCE THE ORDER IS EQUAL TO THE HIGHEST       *00521000
C*              DERIVATIVE USED, THIS RESTRICTS THE ORDER. IT MUST     *00522000
C*              BE LESS THAN 13 FOR ADAMS AND 7 FOR STIFF METHODS.     *00523000
C*    PW      A BLOCK OF AT LEAST N**2 FLOATING POINT LOCATIONS.       *00524000
C***********************************************************************00525000
      DIMENSION Y(13,1), YMAX(1), SAVE(13,1), ERROR(1), PW(1),          00526000
     1          A(13),PERTST(12,2,3),CSAVE(N,3),IP(1)                   00527000
C***********************************************************************00528000
C* THE COEFFICIENTS IN PERTST ARE USED IN SELECTING THE STEP AND       *00529000
C* ORDER, THEREFORE ONLY ABOUT ONE PERCENT ACCURACY IS NEEDED.         *00530000
C***********************************************************************00531000
      DATA PERTST/2.,4.5,7.333,10.42,13.7,17.15,1.,1.,1.,1.,1.,1.,      00532000
     1            12.,12.,24.,37.89,53.33,70.08,87.97,100.9,126.7,147.3,00533000
     2            2168.8,191.4,3.,6.,9.167,12.5,15.98,1.,1.,1.,1.,1.,1.,00534000
     3            1.,312.,24.,37.89,53.33,70.08,87.97,136.9,126.7,147.3,00535000
     4          168.9,4191.4,211.,1.,1.,.5,.1667, 04167,.008333,
     5          1.,1.,1.,1.,1.,51.,1.,1.,2.,1.,.3157, .07407,.0139,
     6          .0021818,.00029,6.000035,.0000037,.00000035  /
      DATA A(2) / -1.0 /
      IRET = 1
      KFLAG = 1
      IF (JSTART.LE.0) GO TO 140
C***********************************************************************
C* BEGIN BY SAVING INFORMATION FOR POSSIBLE RESTARTS AND CHANGING      *
C* H BY THE FACTOR R IF THE CALLER HAS CHANGED H.  ALL VARIABLES       *
C* DEPENDENT ON H MUST ALSO BE CHANGED.                                *
C* E IS A COMPARISON FOR ERRORS OF THE CURRENT ORDER NQ. EUP IS        *
C* TO TEST FOR INCREASING THE ORDER, EDWN FOR DECREASING THE ORDER.    *
C* HNEW IS THE STEP SIZE THAT WAS USED ON THE LAST CALL.               *
C***********************************************************************
 100  DO 110 I = 1,N
        DO 110 J = 1,K
 110      SAVE(J,I) = Y(J,I)
      HOLD = HNEW
      IF (H.EQ.HOLD) GO TO 130
 120  RACUM = H/HOLD
      IRET1 = 1
      GO TO 750
  125 HOLD = H
 130  NQOLD = NQ
      TOLD = T
      RACUM = 1.0
      IF (JSTART.GT.0) GO TO 250
      GO TO 170
 140  IF (JSTART.EQ.-1) GO TO 160
C***********************************************************************
C* ON THE FIRST CALL, THE ORDER IS SET TO 1 AND THE INITIAL            *
C* DERIVATIVES ARE CALCULATED.                                         *
C***********************************************************************
      BR = 1.0
      NQ = 1
      N3 = N
      N4 = N**2
      CALL DIFFUN(T,Y,CSAVE(1,3))
      DO 150 I = 1,N
  150   Y(2,I) = CSAVE(I,3)*H
      HNEW = H
      K = 2
      GO TO 100
C***********************************************************************
C* REPEAT LAST STEP BY RESTORING SAVED INFORMATION.                    *
C***********************************************************************
 160  IF (NQ.EQ.NQOLD) JSTART = 1
      T = TOLD
      NQ = NQOLD
      K = NQ + 1
      GO TO 120
C***********************************************************************
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C* SET THE COEFFICIENTS THAT DETERMINE THE ORDER AND THE METHOD        *00589000
C* TYPE.  CHECK FOR EXCESSIVE ORDER.  THE LAST TWO STATEMENTS OF       *00590000
C* THIS SECTION  SET IWEVAL .GT.0 IF PW IS TO BE RE-EVALUATED          *00591000
C* BECAUSE OF THE ORDER CHANGE, AND THEN REPEAT THE INTEGRATION        *00592000
C* STEP IF IT HAS NOT YET BEEN DONE (IRET = 1) OR SKIP TO A FINAL      *00593000
C* SCALING BEFORE EXIT IF IT HAS BEEN COMPLETED (IRET = 2).            *00594000
C***********************************************************************00595000
 170  IF (MF.EQ.0) GO TO 180                                            00596000
      IF (NQ.GT.6) GO TO 190                                            00597000
      GO TO (221,222,223,224,225,226),NQ                                00598000
  180 IF(NQ.GT.12) GO TO 190                                            00599000
      GO TO (205,206,207,208,209,210,211,212,213,214,215,216), NQ       00600000
 190  KFLAG = -2                                                        00601000
      RETURN                                                            00602000
C***********************************************************************00603000
C* THE FOLLOWING COEFFICIENTS SHOULD BE DEFINED TO THE MAXIMUM         *00604000
C* ACCURACY PERMITTED BY THE MACHINE.  THEY ARE, IN THE ORDER USED..   *00605000
C*                                                                     *00606000
C* -1                                                                  *00607000
C* -1/2,-1/2                                                           *00608000
C* -5/12,-3/4,-1/6                                                     *00609000
C* -3/8,-11/12,-1/3,-1/24                                              *00610000
C* -251/720,-25/24,-35/72,-5/48,-1/120                                 *00611000
C* -95/288,-137/120,-5/8,-17/96,-1/40,-1/720                           *00612000
C* -19087/60480,-49/40,-203/270,-49/192,-7/144,-7/1440,-1/5040         *00613000
C*                                                                     *00614000
C* METHODS TO CALCULATE FURTHER COEFFICIENTS CAN BE FOUND IN           *00615000
C* HENRICI, DISCRETE VARIABLE METHODS IN ORDINARY D. E.                *00616000
C*                                                                     *00617000
C* -1                                                                  *00618000
C* -2/3,-1/3                                                           *00619000
C* -12/25,-7/10,-1/5,-1/50                                             *00620000
C* -120/274,-225/274,-85/274,-15/274,-1/274                            *00621000
C* -180/441,-58/63,-15/36,-25/252,-3/252,-1/1764                       *00622000
C***********************************************************************00623000
  205 A(1) = -1.0                                                       00624000
      GO TO 230                                                         00625000
  206 A(1) = -.50000000000                                              00626000
      A(3) = -0.500000000                                               00627000
      GO TO 230                                                         00628000
  207 A(1) = -0.4166666666666667                                        00629000
      A(3) = -0.750000000                                               00630000
      A(4) = -0.1666666666666667                                        00631000
      GO TO 230                                                         00632000
  208 A(1) = -0.3750000000000                                           00633000
      A(3) = -0.9166666666666667                                        00634000
      A(4) = -0.3333333333333333                                        00635000
      A(5) = -0.04166666666666667                                       00636000
      GO TO 230                                                         00637000
  209 A(1) = -0.3486111111111111                                        00638000
      A(3) = -1.0416666666666667                                        00639000
      A(4) = -0.4861111111111111                                        00640000
      A(5) = -0.1041666666666667                                        00641000
      A(6) = -0.0083333333333333333                                     00642000
      GO TO 230                                                         00643000
  210 A(1) = -0.3298611111111111                                        00644000
      A(3) = -1.1416666666666667                                        00645000
      A(4) = -0.625000000                                               00646000
      A(5) = -0.1770833333333333                                        00647000
      A(6) = -0.0250000000                                              00648000
      A(7) = -0.0013888888888888889                                     00649000
      GO TO 230                                                         00650000
  211 A(1) = -0.3155919312169312                                        00651000
      A(3) = -1.225000000                                               00652000
      A(4) = -0.7518518518518519                                        00653000
      A(5) = -0.2552083333333333                                        00654000
      A(6) = -0.048611111111111111                                      00655000
      A(7) = -0.0048611111111111111                                     00656000
      A(8) = -0.0001984126984126984                                     00657000
      GO TO 230                                                         00658000
  212 A(1) = -0.3042245370370370                                        00659000
      A(3) = -1.2964285714285485                                        00660000
      A(4) = -0.8685185185185185                                        00661000
      A(5) = -0.3357638888888888                                        00662000
      A(6) = -0.077777777777777777                                      00663000
      A(7) = -0.0106481481481481815                                     00664000
      A(8) = -0.0007936507936507937                                     00665000
      A(9) = -0.00002480158730157189                                    00666000
      GO TO 230                                                         00667000
  213 A(1) = -0.2948680004409171                                        00668000
      A(3) = -1.3589285714285505                                        00669000
      A(4) = -0.9765542328041257                                        00670000
      A(5) = -0.4171875000000                                           00671000
      A(6) = -0.1113541666666667                                        00672000
      A(7) = -0.0187450000                                              00673000
      A(8) = -0.0019345238309523809                                     00674000
      A(9) = -0.0001116071428570911                                     00675000
      A(10) = -0.00000275573192239706                                   00676000
      GO TO 230                                                         00677000
  214 A(1) = -0.2869754464285714                                        00678000
      A(3) = -1.414484126983951                                         00679000
      A(4) = -1.077215608465301                                         00680000
      A(5) = -0.4985670194001107                                        00681000
      A(6) = -0.148437500000                                            00682000
      A(7) = -0.0290605709876226                                        00683000
      A(8) = -0.0037202380952323                                        00684000
      A(9) = -0.0002996858465601941                                     00685000
      A(10) = -0.00001377865961195214                                   00686000
      A(11) = -0.00000027557319223878                                   00687000
      GO TO 230                                                         00688000
  215 A(1) = -0.280189564439367                                         00689000
      A(3) = -1.464484126986034                                         00690000
      A(4) = -1.171514550268255                                         00691000
      A(5) = -0.5793581900385553                                        00692000
      A(6) = -0.1883228615536998                                        00693000
      A(7) = -0.0414303626548524З                                       00694000
      A(8) = -0.006211144180002914                                      00695000
      A(9) = -0.000625206679908472O                                     00696000
      A(10) = -0.00004041740152967666                                   00697000
      A(11) = -0.000001515652557372595                                  00698000
      A(12) = -.00000000250521083864932                                 00699000
      GO TO 230                                                         00700000
  216 A(1) = -0.274265540031599                                         00701000
      A(3) = -1.509938672424507                                         00702000
      A(4) = -1.260271163994607                                         00703000
      A(5) = -0.659234182076101                                         00704000
      A(6) = -0.2304580026342793                                        00705000
      A(7) = -0.05569724610169335                                       00706000
      A(8) = -0.009439484126243074                                      00707000
      A(9) = -0.001119274966826774                                      00708000
      A(10) = -0.00009093915342935554                                   00709000
      A(11) = -0.000004822530863610993                                  00710000
      A(12) = -0.0000001503126502923833                                 00711000
      A(13) = -0.000000002087675698479380                               00712000
      GO TO 230                                                         00713000
  221 A(1) = -1.000000000                                               00714000
      GO TO 230                                                         00715000
  222 A(1) = -0.6666666666666667                                        00716000
      A(3) = -0.3333333333333333                                        00717000
      GO TO 230                                                         00718000
  223 A(1) = - 0.5454545454545455                                       00719000
      A(3) = A(1)                                                       00720000
      A(4) = -0.09090909090909091                                       00721000
      GO TO 230                                                         00722000
  224 A(1) = -0.480000000                                               00723000
      A(3) = -0.700000000                                               00724000
      A(4) = -0.200000000                                               00725000
      A(5) = -0.020000000                                               00726000
      GO TO 230                                                         00727000
  225 A(1) = -0.437956204379562                                         00728000
      A(3) = -0.8211678832116788                                        00729000
      A(4) = -0.3102189781021898                                        00730000
      A(5) = -0.05474452554744526                                       00731000
      A(6) = -0.0036496350364963504                                     00732000
      GO TO 230                                                         00733000
  226 A(1) = -0.4081632653061225                                        00734000
      A(3) = -0.9206349206349206                                        00735000
      A(4) = -0.4166666666666667                                        00736000
      A(5) = -0.0992063492063492                                        00737000
      A(6) = -0.0119047619047619                                        00738000
      A(7) = -0.000566893424036282                                      00739000
  230 K = NQ+1                                                          00740000
      IDOUB = K                                                         00741000
      MTYP = (4 - MF)/2                                                 00742000
      ENQ2 = .5/FLOAT(NQ + 1)                                           00743000
      ENQ3 = .5/FLOAT(NQ + 2)                                           00744000
      ENQ1 = 0.5/FLOAT(NQ)                                              00745000
      PEPSH = EPS                                                       00746000
      EUP = (PERTST(NQ,MTYP,2)*PEPSH)**2                                00747000
      E = (PERTST(NQ,MTYP,1)*PEPSH)**2
      EDWN =(PERTST(NQ,MTYP,3)*PEPSH)**2
      IF (EDWN.EQ.0) GO TO 780
      BND = (EPS*ENO3)**2
 240  IWEVAL = MF
      GO TO ( 250 , 680 ),IRET
C*********************************************************************
C* THIS SECTION COMPUTES THE PREDICTED VALUES BY EFFECTIVELY           *
C* MULTIPLYING THE SAVED INFORMATION BY THE PASCAL TRIANGLE           *
C* MATRIX.                                                             *
C*********************************************************************
 250  T = T + H
      DO 260 J = 2,K
        DO 260 J1 = J,K
          J2 = K - J1 + J - 1
          DO 260 I = 1,N
 260        Y(J2,I) = Y(J2,I) + Y(J2+1,I)
C*********************************************************************
C*    UP TO 2 CORRECTOR ITERATIONS ARE TAKEN.  CONVERGENCE IS TESTED BY *
C*    REQUIRING THE L2 NORM OF CHANGES TO BE LESS THAN BND WHICH IS    *
C*    DEPENDENT ON THE ERROR TEST CONSTANT.                            *
C*       THE SUM OF THE CORRECTIONS IS ACCUMULATED IN THE ARRAY        *
C*    ERROR(I).  IT IS EQUAL TO THE K-TH DERIVATIVE OF Y MULTIPLIED    *
C*    BY  H**K/(FACTORIAL(K-1)*A(K)), AND IS THEREFORE PROPORTIONAL    *
C*    TO THE ACTUAL ERRORS TO THE LOWEST POWER OF H PRESENT. (H**K)    *
C*********************************************************************
      DO 270 I = 1,N
 270    ERROR(I) = 0.0
      DO 430   L=1,2
        CALL DIFFUN (T,Y,CSAVE(1,3))
C*********************************************************************
C*    IF THERE HAS BEEN A CHANGE OF ORDER OR THERE HAS BEEN TROUBLE    *
C*    WITH CONVERGENCE, PW IS RE-EVALUATED PRIOR TO STARTING THE       *
C*    CORRECTOR ITERATION IN THE CASE OF STIFF METHODS.  IWEVAL IS     *
C*    THEN SET TO -1 AS AN INDICATOR THAT IT HAS BEEN DONE.            *
C*********************************************************************
      IF (IWEVAL.LT.1) GO TO 350
        IF (MF.EQ.2) GO TO 310
        CALL PEDERV(T,Y,PW,N3)
        R = A(1)*H
        DO 280 I = 1,N4
 280      PW(I) = PW(I)*R
C*********************************************************************
C* ADD THE IDENTITY MATRIX TO THE JACOBIAN AND DECOMPOSE INTO LU = PW *
C*********************************************************************
 290    DO 300 I = 1,N
 300      PW(I*(N3+1)-N3) = 1.0 + PW(I*(N3+1)-N3)
        IWEVAL = -1
      CALL DECOMP(N,N3,PW,IP)
        IF  (IP(N) .NE. 0)  GO TO 350
        GO TO 440
C*********************************************************************
C* EVALUATE THE JACOBIAN INTO PW BY NUMERICAL DIFFERENCING.  R IS THE  *
```

```
C* CHANGE MADE TO THE ELEMENT OF Y.  IT IS EPS RELATIVE TO Y WITH       *00801000
C* A MINIMUM OF EPS**2.  F STORES THE UNCHANGED VALUE OF Y.             *00802000
C***********************************************************************00803000
  310    DO 340 J = 1,N                                                  00804000
      F = Y(1,J)                                                         00805000
         R = EPS*DMAX1(EPS,DABS(F))                                      00806000
         Y(1,J) = Y(1,J) + R                                             00807000
         D = A(1)*H/R                                                    00808000
         CALL DIFFUN(T,Y,CSAVE(1,1))                                     00809000
         DO 330 I = 1,N                                                  00810000
  330      PW(I+(J-1)*N3) = (CSAVE(I,1) -CSAVE(I,3)) * D                 00811000
  340     Y(1,J) = F                                                     00812000
       GO TO 290                                                         00813000
  350      DO 360 I = 1,N                                                00814000
  360       CSAVE(I,1) = Y(2,I) - CSAVE(I,3)*H                           00815000
      IF(MF.EQ.0) GO TO 410                                              00816000
      CALL SOLVE(N,N3,PW,CSAVE(1,1),IP)                                  00817000
C***********************************************************************00818000
C* CORRECT AND COMPARE DEL, THE L2 NORM OF CHANGE/YMAX, WITH BND.       *00819000
C* ESTIMATE THE VALUE OF THE L2 NORM OF THE NEXT CORRECTION BY          *00820000
C* BR*2*DEL AND COMPARE WITH BND.  IF EITHER IS LESS, THE CORRECTOR     *00821000
C* IS SAID TO HAVE CONVERGED.                                           *00822000
C***********************************************************************00823000
  410 DEL = 0.0D0                                                        00824000
        DO 420 I = 1,N                                                   00825000
          Y(1,I) = Y(1,I) + A(1)*CSAVE(I,1)                              00826000
          Y(2,I) = Y(2,I) - CSAVE(I,1)                                   00827000
          ERROR(I) = ERROR(I) + CSAVE(I,1)                               00828000
      DEL = DEL + (CSAVE(I,1)/YMAX(I))**2                                00829000
 420      CONTINUE                                                       00830000
  426 IF(L.GE.2) BR = DMAX1(.9*BR, DEL/DEL1)                             00831000
      DEL1 = DEL                                                         00832000
      IF(DMIN1(DEL,BR*DEL*2.0)  .LE.  BND)  GO TO 490                    00833000
 430     CONTINUE                                                        00834000
C***********************************************************************00835000
C* THE CORRECTOR ITERATION FAILED TO CONVERGE IN 2 TRIES.  VARIOUS      *00836000
C* POSSIBILITIES ARE CHECKED FOR.  IF H IS ALREADY HMIN AND             *00837000
C* THIS IS EITHER ADAMS METHOD OR THE STIFF METHOD IN WHICH THE         *00838000
C* MATRIX PW HAS ALREADY BEEN RE-EVALUATED, A NO CONVERGENCE EXIT       *00839000
C* IS TAKEN. OTHERWISE THE MATRIX PW IS RE-EVALUATED AND/OR THE         *00840000
C* STEP IS REDUCED TO TRY AND GET CONVERGENCE.                          *00841000
C***********************************************************************00842000
 440  T = TOLD                                                           00843000
      IF ((H.LE.(HMIN*1.00001)).AND.((IWEVAL - MTYP).LT.-1)) GO TO 460   00844000
      IF ((MF.EQ.0).OR.(IWEVAL.NE.0)) RACUM = RACUM*0.25D0               00845000
      IWEVAL = MF                                                        00846000
      IRET1 = 2                                                          00847000
      GO TO 750                                                          00848000
 460  KFLAG = -3                                                         00849000
      NQ = NQOLD                                                         00850000
 470  DO 480 I = 1,N                                                     00851000
        DO 480 J = 1,K                                                   00852000
 480      Y(J,I) = SAVE(J,I)                                             00853000
```

```

      H = HOLD
      JSTART = NQ
      RETURN
C***********************************************************************
C* THE CORRECTOR CONVERGED AND CONTROL IS PASSED TO STATEMENT 520      *
C* IF THE ERROR TEST IS O.K.,  AND TO 540 OTHERWISE.                    *
C* IF THE STEP IS O.K. IT IS ACCEPTED. IF IDOUB HAS BEEN REDUCED       *
C* TO ONE,  A TEST IS MADE TO SEE IF THE STEP CAN BE INCREASED         *
C* AT THE CURRENT ORDER OR BY GOING TO ONE HIGHER OR ONE LOWER.        *
C* SUCH A CHANGE IS ONLY MADE IF THE STEP CAN BE INCREASED BY AT       *
C* LEAST 1.19  IF NO CHANGE IS POSSIBLE IDOUB IS SET TO 8 TO           *
C* PREVENT FUTHER TESTING FOR 8 STEPS.                                 *
C* IF A CHANGE IS POSSIBLE, IT IS MADE AND IDOUB IS SET TO             *
C* NQ + 1    TO PREVENT FURTHER TESING FOR THAT NUMBER OF STEPS.       *
C* IF THE ERROR WAS TOO LARGE, THE OPTIMUM STEP SIZE FOR THIS OR       *
C* LOWER ORDER IS COMPUTED, AND THE STEP RETRIED.  IF IT SHOULD        *
C* FAIL TWICE MORE IT IS AN INDICATION THAT THE DERIVATIVES THAT       *
C* HAVE ACCUMULATED IN THE Y ARRAY HAVE ERRORS OF THE WRONG ORDER      *
C* SO THE FIRST DERIVATIVES ARE RECOMPUTED AND THE ORDER IS SET        *
C* TO 1.                                                               *
C***********************************************************************
  490 D = 0.0
      DO 500 I = 1,N
  500   D = D + (ERROR(I)/YMAX(I))**2
      IWEVAL = 0
      IF (D.GT.E) GO TO 540
      IF (K.LT.3) GO TO 520
C***********************************************************************
C* COMPLETE THE CORRECTION OF THE HIGHER ORDER DERIVATIVES AFTER A     *
C* SUCCESFUL STEP.                                                     *
C***********************************************************************
      DO 510 J = 3,K
        DO 510 I = 1,N
  510     Y(J,I) = Y(J,I) + A(J)*ERROR(I)
  520 KFLAG = +1
      HNEW = H
      IF (IDOUB.LE.1) GO TO 550
      IDOUB = IDOUB - 1
      IF (IDOUB.GT.1) GO TO 700
      DO 530 I = 1,N
  530   CSAVE(I,2) = ERROR(I)
      GO TO 700
C***********************************************************************
C* REDUCE THE FAILURE FLAG COUNT TO CHECK FOR MULTIPLE FAILURES.       *
C* RESTORE T TO ITS ORIGINAL VALUE AND TRY AGAIN UNLESS THERE HAVE     *
C* THREE FAILURES.  IN THAT CASE THE DERIVATIVES ARE ASSUMED TO HAVE   *
C* ACCUMULATED ERRORS SO A RESTART FROM THE CURRENT VALUES OF Y IS     *
C* TRIED. THIS IS CONTINUED UNTIL SUCCESS OR H = HMIN.                 *
C***********************************************************************
  540 KFLAG = KFLAG - 2
      IF (H.LE.(HMIN*1.00001)) GO TO 740
      T = TOLD
      IF (KFLAG.LE.-5) GO TO 720
```

```
C***********************************************************************
C* PR1, PR2, AND PR3  WILL CONTAIN THE AMOUNTS BY WHICH THE STEP SIZE  *
C* CHOULD BE DIVIDED AT ORDER ONE LOWER, AT THIS ORDER, AND AT ORDER   *
C* ONE HIGHER RESPECTIVELY.                                            *
C***********************************************************************
  550 PR2 = (D/E)**ENQ2*1.2
      PR3 = 1.E+20
      IF ((NQ.GE.MAXDER).OR.(KFLAG.LE.-1)) GO TO 570
      D = 0.0
      DO 560 I = 1,N
  560   D = D + ((ERROR(I) - CSAVE(I,2))/YMAX(I))**2
      PR3 = (D/EUP)**ENQ3*1.4
  570 PR1 = 1.E+20
      IF (NQ.LE.1) GO TO 590
      D = 0.0
      DO 580 I = 1,N
  580   D = D + (Y(K,I)/YMAX(I))**2
      PR1 = (D/EDWN)**ENQ1*1.3
  590 CONTINUE
      IF (PR2.LE.PR3) GO TO 650
      IF (PR3.LT.PR1) GO TO 660
  600 R = 1.0/AMAX1(PR1,1.E-4)
      NEWQ = NQ - 1
  610 IDOUB = 8
      IF ((KFLAG.EQ.1).AND.(R.LT.(1.1))) GO TO 700
      IF (NEWQ.LE.NQ) GO TO 630
C***********************************************************************
C* COMPUTE ONE ADDITIONAL SCALED DERIVATIVE IF ORDER IS INCREASED.     *
C***********************************************************************
      DO 620 I = 1,N
  620   Y(NEWQ+1,I) = ERROR(I)*A(K)/DFLOAT(K)
  630 K = NEWQ + 1
      IF (KFLAG.EQ.1) GO TO 670
      RACUM = RACUM*R
      IRET1 = 3
      GO TO 750
  640 IF (NEWQ.EQ.NQ) GO TO 250
      NQ = NEWQ
      GO TO 170
  650 IF (PR2.GT.PR1) GO TO 600
      NEWQ = NQ
      R = 1.0/AMAX1(PR2,1.E-4)
      GO TO 610
  660 R = 1.0/AMAX1(PR3,1.E-4)
      NEWQ = NQ + 1
      GO TO 610
  670 IRET = 2
      R = DMIN1(R,HMAX/DABS(H))
      H = H*R
      HNEW = H
      IF (NQ.EQ.NEWQ) GO TO 680
      NQ = NEWQ
      GO TO 170
```

```
680  R1 = 1.0
     DO 690 J = 2,K
       R1 = R1*R
       DO 690 I = 1,N
690      Y(J,I) = Y(J,I)*R1
     IDOUB = K
700  DO 710 I = 1,N
710    YMAX(I) = DMAX1(YMAX(I),DABS(Y(1,I)))
     JSTART = NQ
     RETURN
720  IF(NQ.GT.1) GO TO 725
     IF (H .LE. 2.D0*HMIN)  GO TO 780
     GO TO 550
 725 DO 730   I= 1,N
       Y(1,I) = SAVE(1,I)
       SAVE(2,I) = HOLD*CSAVE(I,3)
730    Y(2,I) = SAVE(2,I)*R
     R = H/HOLD
     CALL DIFFUN (T,Y,CSAVE(1,3))
     NQ = 1
     KFLAG = 1
     GO TO 170
740  KFLAG = -1
     HNEW = H
     JSTART = NQ
     RETURN
C***********************************************************************
C* THIS SECTION SCALES ALL VARIABLES CONNECTED WITH H AND RETURNS      *
C* TO THE ENTERING SECTION.                                            *
C***********************************************************************
750  RACUM = DMAX1(DABS(HMIN/HOLD),RACUM)
     RACUM = DMIN1(RACUM,DABS(HMAX/HOLD))
     R1 = 1.0
     DO 760 J = 2,K
       R1 = R1*RACUM
       DO 760 I = 1,N
760      Y(J,I) = SAVE(J,I)*R1
     H = HOLD*RACUM
     DO 770 I = 1,N
770    Y(1,I) = SAVE(1,I)
     IDOUB = K
     GO TO ( 125 , 250 , 640 ),IRET1
780  KFLAG = -4
     GO TO 470
     END
```

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IAY 71)                                   OS/360  FORTRAN H

IPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=55,SIZE=0000K,
                 SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
      SUBROUTINE DECOMP(N,NDIM,A,IP)
      IMPLICIT REAL*8(B-H,O-Z)
C
C     MATRIX TRIANGULARIZATION BY GAUSSIAN ELIMINATION.
C
C    INPUT...
C      N = ORDER OF MATRIX
C      NDIM = DECLARED DIMENSION OF ARRAY A.
C      A = MATRIX TO BE TRIANGULARIZED. (FOR STIFF METHODS, A IS SINGLE
C                PRECISION;  ALL OTHER VARIABLE ARE DOUBLE PRECISION.)
C    OUTPUT...
C      A(I,J),  I.LE.J  = UPPER TRIANGULAR FACTOR, U.
C      A(I,J),    I.GT.J   = MULTIPLIERS  = LOWER TRIANGULAR FACTOR, I-L.
C      IP(K),  K.LT.N = INDEX OF K-TH PIVOT ROW.
C      IP(N)   = (-1)**(NUMBER OF INTERCHANGES) OR 0.
C    USE 'SOLVE' TO OBTAIN SOLUTION OF LINEAR SYSTEM.
C    DETERM(A) = IP(N)*A(1,1)*A(2,2)*...*A(N,N).
C    IF IP(N) = 0, A IS SINGULAR, SOLVE WILL DIVIDE BY ZERO.
C
      DIMENSION A(NDIM,NDIM),IP(NDIM)
      DIMENSION B(4,4)
      COMMON NFNS,NW,B
      NW = NW + 1
      IP(N) = 1
      DO 6  K=1,N
      IF(K.EQ.N) GO TO 5
      KP1 = K+1
      M = K
      DO 1  I=KP1,N
      IF(ABS(A(I,K)).GT.ABS(A(M,K)))   M=I
    1 CONTINUE
      IP(K) = M
      IF(M.NE.K)  IP(N) = -IP(N)
      T = A(M,K)
      A(M,K) = A(K,K)
      A(K,K) = T
      IF(T.EQ.0) GO TO 5
      DO 2  I=KP1,N
    2   A(I,K) = -A(I,K) / T
      DO 4  J=KP1,N
      T = A(M,J)
      A(M,J) = A(K,J)
      A(K,J) = T
      IF(T.EQ.0.) GO TO 4
      DO 3   I=KP1,N
    3     A(I,J) = A(I,J) + A(I,K)*T
    4  CONTINUE
    5 IF(A(K,K).EQ.0.) IP(N) = 0
    6 CONTINUE
      RETURN
      END
```

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                              OS/360  FORTRAN H

COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=55,SIZE=0000K,
                  SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
      SUBROUTINE SOLVE(N,NDIM,A,B,IP)
      IMPLICIT REAL*8 (B-H,Q-Z)
C
C   SOLUTION OF LINEAR SYSTEM, A*X = B.
C
C   INPUT...
C     N = ORDER OF MATRIX.
C     NDIM = DECLARED DIMENSION OF ARRAY A.
C     A = TRIANGULARIZED MATRIX OBTAINED FROM 'DECOMP'.
C     B = RIGHT HAND SIDE VECTOR.
C     IP = PIVOT VECTOR OBTAINED FROM 'DECOMP'.
C   OUTPUT...
C     B = SOLUTION VECTOR, X.
      DIMENSION A(NDIM,NDIM), B(NDIM), IP(NDIM)
      IF(N.EQ.1) GO TO 9
      NM1 = N-1
      DO 7  K=1,NM1
         KP1 = K + 1
         M = IP(K)
      T = B(M)
      B(M) = B(K)
      B(K) = T
      DO 7  I=KP1,N
    7 B(I) = B(I) + A(I,K)*T
      DO 8   KB=1,NM1
      KM1 = N - KB
      K = KM1 + 1
      B(K) = B(K)/A(K,K)
      T = -B(K)
      DO 8  I=1,KM1
    8 B(I) = B(I) + A(I,K)*T
    9 B(1) = B(1)/A(1,1)
      RETURN
      END
```

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                                 OS/360  FORTRAN H

COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=55,SIZE=0000K,
                   SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
       SUBROUTINE PEDERV (T,Y,PW,N3)                                    01089300
       DIMENSION Y(13,40),PW(1600)                                      01089320
       DOUBLE PRECISION T,Y                                             01089340
       RETURN                                                           01089360
       END                                                              01089380
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                                    OS/360  FORTRAN H

COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=55,SIZE=0000K,
                  SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
      SUBROUTINE SMGOUT (X,Y,H)                                          01090000
      DIMENSION Y(40)                                                    01091000
      DOUBLE PRECISION X,Y,Z,DERY,D,ZZ,H,PRMT,YY,C,BB,POLL               01092000
      REAL*8 LABEL,RCT                                                   01093000
      COMMON /KINCOM/ ZZ(4),YY(40),LABEL(40),D(50),RCT(50,3),PRMT(8),    01094000
     1       DERY(40),C(50),BB,Z(2),N,NC,NEQ,NDIF,KDIF,M,NN,INTR,NNC,    01095000
     2       NNDIF,IUV,IM,IS,ITRAF,NLL,CC(16,100),A(80),STEP(15),TIM1,   01096000
     3       TIM2,TIM4,PEAK1,TIME1,PEAK3,TIME3,XPOS,YPOS                 01097000
C                                                                        01098000
      COMMON /ALLCOM/ POLL(4,3),GPOLL(4,3),ANS(8),GOTIME,XDEPTH,ISOUR,   01099000
     1                XDEPRV                                             01099200
C                                                                        01100000
      EQUIVALENCE (TEMP,ANS(3)),(HUMID,ANS(4)),(HT,ANS(7)),(XHT,ANS(8)) 01101000
C                                                                        01102000
C                                                                        01103000
      IF (NN.EQ.1.AND.BB.EQ.0.1E02) GO TO 4                              01104000
      IF (BB-PRMT(7))   400,4,4                                          01105000
C                                                                        01106000
C     SAVE VALUES FOR THE PLOTS.                                         01107000
C                                                                        01108000
    4 IF (NEQ .EQ. 1)    GO TO 110                                       01109000
      IF (NN .EQ. 101)   NN=100                                          01109200
      CC(1,NN) = X                                                       01110000
      DO 10  I=1,NDIF                                                    01111000
   10 CC(I+1,NN) = Y(I)                                                  01112000
      IF (1.0E08-BB)110,20,30                                            01113000
C                                                                        01114000
   20 PEAK1 = Y(1)                                                       01114200
      TIME1= X                                                           01115000
      PEAK3= Y(3)                                                        01116000
      TIME3= X                                                           01117000
C                                                                        01118000
C     HAL1---HALF VALUE OF SPECIES 1                                     01119000
C     HAL2---HALF VALUE OF SPECIES 2                                     01120000
C     HAL4---HALF VALUE OF SPECIES 4                                     01121000
C                                                                        01122000
      HAL1=Y(1)/2.0                                                      01123000
      HAL2=Y(2)/2.0                                                      01124000
      HAL4=Y(4)/2.0                                                      01125000
      PREVY1 = Y(1)                                                      01126000
      PREVY2 = Y(2)                                                      01127000
      PREVY4 = Y(4)                                                      01128000
      TIM1 = 0.0                                                         01129000
      TIM2 = 0.0                                                         01130000
      TIM4 = 0.0                                                         01131000
      PTIM1=0.0                                                          01132000
      PTIM2=0.0                                                          01133000
      PTIM4=0.0                                                          01134000
C                                                                        01135000
      GO TO 110                                                          01136000
C                                                                        01137000
```

```
C     SAVE PEAK VALUES, PEAK TIMES, AND HALF-TIMES.
C
   30 IF (Y(1).LT.PEAK1) GO TO 40
      PEAK1= Y(1)
      TIME1= X
   40 IF (Y(3).LT.PEAK3) GO TO 70
      PEAK3= Y(3)
      TIME3= X
   70 IF (Y(1)-PREVY1) 71, 71, 80
   71 IF (Y(1).GT.HAL1.OR.PREVY1.LT.HAL1) GO TO 73
      TIM1=PTIM1-(PTIM1-X)*((PREVY1-HAL1)/(PREVY1-Y(1)))
   73 PREVY1=Y(1)
      PTIM1=X
   80 IF (Y(2)-PREVY2) 81, 81, 90
   81 IF (Y(2).GT.HAL2.OR.PREVY2.LT.HAL2) GO TO 83
      TIM2=PTIM2-(PTIM2-X)*((PREVY2-HAL2)/(PREVY2-Y(2)))
   83 PREVY2=Y(2)
      PTIM2=X
   90 IF (Y(4)-PREVY4) 91, 91,110
   91 IF (Y(4).GT.HAL4.OR.PREVY4.LT.HAL4) GO TO 93
      TIM4=PTIM4-(PTIM4-X)*((PREVY4-HAL4)/(PREVY4-Y(4)))
   93 PREVY4=Y(4)
      PTIM4=X
C
C     CHECK IF OUTPUT THIS TIME.
C
  110 IF (INTR)  130,130,120
  120 IF (X .LT. (STEP(M)-0.5)) GO TO 170
  130 WRITE (6,1000) X,NN,XPOS,YPOS,H,M
      IF (ITRAF .EQ. 0 .AND. ISOUR .EQ. 0)   GO TO 145
      WRITE (6,1012)
      IF (ITRAF .EQ. 0)  GO TO 140
      WRITE (6,1013) (POLL(I,1),I=1,4),(GPOLL(I,1),I=1,4)
      WRITE (6,1007) (POLL(I,2),I=1,4),(GPOLL(I,2),I=1,4)
  140 IF (ISOUR .EQ. 0)  GO TO 145
      WRITE (6,1011) POLL(1,3),POLL(2,3),POLL(4,3),GPOLL(1,3),GPOLL(2,3)
     1               ,GPOLL(4,3)
  145 WRITE (6,1009)
      WRITE (6,1010) TEMP,HUMID,HT,XHT,XDEPTH
      WRITE (6,1001)
      WRITE (6,1002) (I,LABEL(I),Y(I),DERY(I),I=1,NDIF)
      DO 150  J=NNDIF,NC
      WRITE (6,1003)  J,LABEL(J),YY(J)
  150 CONTINUE
      IF (NEQ .EQ. 1)    GO TO 160
      WRITE (6,1005)
      WRITE (6,1006) (I,(RCT(I,J),J=1,3),D(I),I=1,NEQ)
  160 M = M+1
  170 IF (BB .EQ. 1.0E+08)  GO TO 180
      NN=NN+1
  180 BB = 0.0
C
C     CHECK FOR NEGATIVE CONCENTRATIONS OF SPECIES.
```

```
C                                                                       01186000
  400 DO 405  I=1,NDIF                                                  01187000
      IF (Y(I))  401,405,405                                            01188000
  401 Y(I) = 0.                                                         01189000
  405 CONTINUE                                                          01190000
      DO 415  I=NNDIF,NC                                                01191000
      IF (YY(I))  411,415,415                                           01192000
  411 YY(I) = 0.                                                        01193000
  415 CONTINUE                                                          01194000
      BB=BB+1.0                                                         01195000
      RETURN                                                            01196000
 1000 FORMAT('1','TIME=',D15.8,' MINUTES',5X,'STEP=',I3,5X,'POSITION=', 01197000
     1F8.4,',',F8.4,6X,'STEP SIZE=',D15.8,6X,'PAGE',I4,///)             01198000
C                                                                       01199000
 1001 FORMAT(//'     COMPOUND   CONC PPHM    CHANGE, PPHM/MIN')         01200000
 1002 FORMAT(' ',I3,1X,A8,2D16.7)                                       01201000
 1003 FORMAT(' ',I3,1X,A8,D16.7)                                        01202000
 1005 FORMAT('1',16X,'RATES OF REACTION'/)                              01203000
 1006 FORMAT(I4,4X,3A8,D16.5)                                           01204000
 1007 FORMAT('OFREEWAY TRAFFIC',4X,4D12.4,4X,4E12.4)                    01205000
C                                                                       01206000
C                                                                       01207000
C                                                                       01208000
 1008 FORMAT ('ODIFFUSION EMISSIONS IN GRAMS/MIN',6X,'NO2=',E15.8,      01209000
     1 6X,'NO=',E15.8)                                                  01210000
 1009 FORMAT(//1HO,16X,'RELATIVE'                          ,18X,'MIXING',  01211000
     16X,'MIXING',/'  TEMPERATURE    HUMIDITY',                      '  E01212000
     2LEVATION',6X,'HEIGHT',7X,'DEPTH',/6X,'(CENT.)                 ',   01213000
     3                '    (METERS)    (METERS)     (METERS)')          01214000
 1010 FORMAT(1HO,5F12.4)                                                01215000
 1011 FORMAT('OAREA SOURCES',7X,2D12.4,12X,D12.4,4X,2E12.4,12X,E12.4///)01216000
 1012 FORMAT(30X,'EXPECTED RATE OF CHANGE OF CONCENTRATIONS DUE TO EMISS01216110
     1IONS FROM REGIONAL SOURCES'//40X,'PPHM/MIN',42X,'GRAM-MOLES/MIN'//01216120
     222X,'PROPYLENE',7X,'NO',10X,'CO',8X,'DUMHC',9X,'PROPYLENE',7X,'NO'01216130
     3,10X,'CO',8X,'DUMHC')                                             01216140
 1013 FORMAT('OSTREET TRAFFIC',5X,4D12.4,4X,4E12.4)                     01217000
      END                                                               01218000
```

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                              OS/360  FORTRAN H

COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=55,SIZE=0000K,
             SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF                 01219000
      SUBROUTINE DIFFUN (X,YSAVE,DY)                                            01220000
      DIMENSION YSAVE(13,40),Y(40),DY(40)                                       01221000
      DOUBLE PRECISION YSAVE,Y,DY,C,D,Z,X,YY,ZZ,3B,DERY,POLL,PRMT,XPREV 01222000
      REAL*8 LABEL,RCT                                                          01223000
      COMMON /KINCOM/ ZZ(4),YY(40),LABEL(40),D(50),RCT(50,3),PRMT(8),           01224000
     1      DERY(40),C(50),3B,Z(2),N,NC,NEQ,NDIF,KDIF,M,NN,INTR,NNC,            01225000
     2      NNDIF,IUV,IM,IS,ITRAF,NLL,CC(16,100),A(80),STEP(15),TIM1,           01226000
     3      TIM2,TIM4,PEAK1,TIME1,PEAK3,TIME3,XPOS,YPOS                         01227000
C                                                                               01228000
      COMMON /ALLCOM/ POLL(4,3),GPOLL(4,3),ANS(8),GOTIME,XDEPTH,ISOUR,          01228200
     1                XDEPRV                                                    01229000
      DO 2  I=1,NC                                                              01230000
    2 Y(I) = YSAVE(1,I)                                                         01230200
      IF (NEQ.EQ. 1)    GO TO 18                                                01231000
C                                                                               01232000
C     COMPUTE NON-ACCUMULAING SPECIES.                                          01233000
C                                                                               01234000
      IF (Y(2)) 6,6,8                                                           01235000
    6 Y(2) = (D(1)        )/(C(3: *Y(3)+C(6)*Y(24)           +C(8)*Y(16)+  01236000
     1C(16)*Y(19) + C(17)*Y(18) + C(18)*Y(25) + C(19)*Y(21) +                   01237000
     2C(20)*Y(22))                                                              01238000
      DERY(2) = 0.                                                              01238500
C                                                                               01239000
    8 YY(14) = (D(14)*100.D0+2.D0*D(32))/(C(9)+ZZ(3))                           01240000
C                                                                               01241000
      YY(15) = (D(8)+D(11)+D(25))/                                              01242000
     1         (C(7)*Y(4)+C(12)*Y(1)+C(13)*Y(3)+C(14)*100.D0*Y(8)+ZZ(3))01243000
C                                                                               01244000
      YY(16) = (D(9)+D(13)+D(21))/(C(8)*Y(2)+C(26)*Y(4)+ZZ(3))                  01245000
C                                                                               01246000
      YY(17) = (D(7)+D(22)+D(27)+D(28)+D(31))/(C(15)+ZZ(3))                     01247000
C                                                                               01248000
      YY(18) = (D(11)+D(16)+D(26)+D(27))/                                       01249000
     1         (C(17)*Y(2)+C(21)+C(29)*Y(1)+ZZ(3))                              01250000
C                                                                               01251000
      YY(19) = (D(15)+D(17))/(C(16)*Y(2)+C(27)*Y(4)+ZZ(3))                      01252000
C                                                                               01253000
      YY(20) = (D(19)+D(22)+D(27)+D(31))/(C(10)+C(28)+ZZ(3))                    01254000
C                                                                               01255000
      YY(21) = (D(5)+D(18))/(C(19)*Y(2)+ZZ(3))                                  01256000
C                                                                               01257000
      YY(22) = (D(23)+D(24))/(C(20)*Y(2)+C(25))                                 01258000
C                                                                               01259000
      YY(23) = D(1)/(C(2)+C(22)*Y(4)+C(24)*Y(4)+C(31)*Y(12))                    01260000
C                                                                               01261000
      YY(24) = D(4)/(C(6)*Y(2)+C(33)*Y(1))                                      01262000
C                                                                               01263000
      YY(25) = (D(10)+D(25))/(C(18)*Y(2)+C(30)*Y(1)+C(5)+ZZ(3))                 01264000
C                                                                               01265000
C     TEST FOR NEGATIVE SOLID STATE SPECIES                                     01266000
C
```

```
      DO 10  I=NNDIF,NC
      IF (YY(I) .LT. 0.0)   YY(I) = 0.0
   10 CONTINUE
C
C     COMPUTE CHAIN YIELD.
C
      ZZ(2) = YY(14)+YY(15)+YY(16)+YY(17)+YY(18)+YY(19)+YY(20)+YY(21)+
     1        YY(25)
      ZZ(3) = ZZ(2)*Z(1)+Y(2)*Z(2)
C
C     SET TRAJECTORY POSITION
C
   13 XPOS = Y(NDIF+1)
      YPOS = Y(NDIF+2)
C
      CALL METEOR (XPOS,YPOS,0,X,XPREV,DERY(NDIF+1),DERY(NDIF+2))
      IF (NEQ .EQ. 1)   GO TO 40
C
      IF (IUV .NE. 0)   GO TO 20
      CALL ULTRAV (C(1))
   20 IUV = IUV+1
      IF (IUV .GT. 100)  IUV=0
C
C     COMPUTE RATES OF REACTION.
C
      D(1) = C(1)*Y(1)
      D( 2) = C( 2)*YY(23)
      IF (Y(2) .LE. 0.0)
     1 Y(2) = (D(1))/(C(3)*Y(3)+C(6)*YY(24)+C(8)*YY(16)+C(16)*YY(19)+
     2              C(17)*YY(18)+C(18)*YY(25)+C(19)*YY(21)+C(20)*YY(22))
C
      D( 3) = C( 3)*Y( 3)*Y(2)
      D( 4) = C( 4)*Y( 1)*Y(3)
      D( 5) = C( 5)*YY(25)
      D( 6) = C( 6)*YY(24)*Y(2)
      D( 7) = C( 7)*YY(15)*Y(4)
      D( 8) = C( 8)*YY(16)*Y(2)
      D( 9) = C( 9)*YY(14)
      D(10) = C(10)*YY(20)
      D(11) = 0.D0
      D(12) = C(12)*YY(15)*Y(1)
      D(13) = C(13)*YY(15)*Y(3)
      D(14) = C(14)*YY(15)*Y(8)
      D(15) = C(15)*YY(17)
      D(16) = C(16)*YY(19)*Y(2)
      D(17) = C(17)*YY(18)*Y(2)
      D(18) = C(18)*YY(25)*Y(2)
      D(19) = C(19)*YY(21)*Y(2)
      D(20) = C(20)*YY(22)*Y(2)
      D(21) = C(21)*YY(18)
      D(22) = C(22)*YY(23)*Y(4)
      D(23) = C(23)* Y( 4)*Y(3)
      D(24) = C(24)*YY(23)*Y(4)
      D(25) = C(25)*YY(22)
      D(26) = C(26)*YY(16)*Y(4)
      D(27) = C(27)*YY(19)*Y(4)
      D(28) = C(28)*YY(20)
      D(29) = C(29)*YY(18)*Y(1)
      D(30) = C(30)*YY(25)*Y(1)
      D(31) = C(31)*YY(23)*Y(12)
      D(32) = C(32)* Y( 7)
      D(33) = C(33)*YY(24)*Y(1)
C
C     COMPUTE RATES OF CHANGE.
C
       DERY( 1)=+D( 3)+D( 6)+D( 6)      +D( 8)      +D(16)+D(17)+D(18)
     1+D(19)+D(20)-D( 1)-D( 4)             -D(12)-D(29)-D(30) -D(33)
       DERY( 2)=+D( 1)      -D( 3)-D( 6)      -D( 8)      -D(16)-D(17)
     1-D(18)-D(19)-D(20)
      DERY(3) = D(2)-D(3)-D(4)+D(5)-D(13)-D(23)
      DERY( 4)=-D(22)-D(23)-D(24)-D(26)-D(27)-D(7)
       DERY( 5)=        + D(12)   + D(33) + D(33)
       DERY( 6)=+D(20)+D(26) + D(7)
      DERY(7)=+D(21)+D(23)+D(24)-D(32)
      DERY (8) = -D(14) + (D(28)+D(32))/100.D0
       DERY( 9)=+D(29)
       DERY(10)=+D(30)
      DERY(11) = 0.D0
C
C
      DERY(12) = -D(31)
C
   40 IF (ISOUR .EQ. 0 .AND. ITRAF .EQ. 0)   GO TO 65
      IF (XPOS .LE. 18. .OR. XPOS .GE. 66.)   GO TO 55
      IF (YPOS .LE. 2.  .OR. YPOS .GE. 52.)   GO TO 65
C
   45 CALL SOURCE (XPOS,YPOS)
C
   55 IF (NEQ .EQ. 1)    GO TO 60
      DERY(2) = DERY(2) + POLL(2,1)+POLL(2,2)+POLL(2,3)
      DERY(4) = DERY(4) + POLL(1,1)+POLL(1,2)+POLL(1,3)
      DERY(8) = DERY(8) + (POLL(3,1)+POLL(3,2))/100.D0
      DERY(12) = DERY(12) + POLL(4,1)+POLL(4,2)+POLL(4,3)
      GO TO 65
   60 DERY(1) = (POLL(3,1)+POLL(3,2))/100.D0
   65 IF (XDEPTH .LE. XDEPRV)   GO TO 80
      IF (X .EQ. XPREV)  GO TO 80
      STORE = ((XDEPRV-XDEPTH)*XDEPRV)/((X-XPREV)*XDEPTH*XDEPTH)
C
C     MODIFY CONCENTRATIONS DUE TO CHANGE IN MIXING DEPTH
C
      DO 70  I=1,NDIF
   70 DERY(I) = DERY(I)+Y(I)*STORE
C
   80 DO 131  I=1,KDIF
      DY(I) = DERY(I)
  131 YSAVE(1,I) = Y(I)
  200 RETURN
      END
```

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                                       OS/360  FORTRAN H

COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=55,SIZE=0000K,
                 SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
            SUBROUTINE METEOR (X,Y,IIDD,XTIME,XPREV,XXDOT,YYDOT)                01363000
      C                                                                         01364000
      C     ARRAYS                                                              01365000
      C     AIR--12 HOURLY AVERAGES OF SIX VARIABLES FOR EACH STATION.          01366000
      C           WIND SPEED AND DIRECTION, TEMPERATURE, HUMIDITY, BAROMETRIC   01367000
      C           PRESSURE, AND CLOUD COVER.                                    01368000
      C     ANS--METEOROLOGICAL DATA FOR AN INTERPOLATED POINT.                 01369000
      C     ARADIO--AM RADIOSONDE CURVE                                         01370000
      C     DISINV--DISTANCE INVERSES, INTERPOLATED POINT TO STATIONS.          01371000
      C     DIST--DISTANCES SQUARED FROM INTERPOLATED POINT TO STATIONS.        01372000
      C     JBAR--BARRIER CHECK INDICATORS, 1 MEANS ELIGIBLE STATION.           01373000
      C     PRADIO--PM RADIOSONDE CURVE                                         01374000
      C     RADIO--RADIOSONDE CURVE                                             01375000
      C     RSLOPE--SLOPES OF RADIOSONDE CURVE SEGMENTS                         01376000
      C     WPOS--NSTA STATION LOCATIONS, THREE DIMENSIONS                      01377000
      C                                                                         01378000
      C                                                                         01379000
            DIMENSION DIST(32),JBAR(32),RADIO(15,2),RSLOPE(14),JFUSE(32,32),    01380000
           1          DISINV(8),VAL1(8),VAL2(8)                                 01381000
      C                                                                         01382000
            COMMON /MYCOM/ TIME,ICLOUD,IDM,IDU,IDD,IDS,IPST,NSTA,NSTACK,NRAD,   01383000
           1          AIR(12,32,6),WPOS(32,3),POS(32,3),SPOS(32,3),HS(12),      01384000
           2          DS(12),VS(12),TS(12),QS(12),SBAROM,STEMP,XDOT,YDOT,       01385000
           3          ARADIO(15,2),PRADIO(15,2),ZENITH(12,2),SGRID(650),        01386000
           4          FGRID(650),AGRID1(650),AGRID2(650),AGRID4(650),EMIT(10),  01387000
           5          XHITE(12),IHT,XMIN                                        01388000
            COMMON /ALLCOM/ POLL(4,3),GPOLL(4,3),ANS(8),GLTIME,XDEPTH,ISOUR,    01389000
           1                XDEPRV                                              01389200
      C                                                                         01390000
            EQUIVALENCE (TEMP,ANS(3)),(HT,ANS(7)),(XHT,ANS(8))                  01391000
      C                                                                         01392000
      C     PRESET DATA                                                         01393000
            DATA SLOPE/-.00986/                                                 01394000
            DOUBLE PRECISION XTIME,XTIME1,XPREV,POLL                            01395000
      C                                                                         01396000
      C     INITIALIZATION                                                      01397000
      C                                                                         01398000
            NPTS = 0                                                            01399000
            DO 10  I=1,8                                                        01400000
            ANS(I) = 0.                                                         01401000
            DISINV(I) = 0.                                                      01402000
            VAL1(I) = 0.                                                        01403000
         10 VAL2(I) = 0.                                                        01404000
            TIME = GOTIME + XTIME/60.                                           01405000
            ITIME = TIME - 6.                                                   01406000
            HOUR = ITIME+6                                                      01407000
            TIMEHR = TIME-HOUR                                                  01408000
      C                                                                         01409000
         20 IF (IDM .EQ. 1)  GO TO 75                                           01410000
            XDEPTH = 0.                                                         01411000
            XTIME1 = 0.D0                                                       01412000
```

```
C
C
C
C
C
C
C
C
C
   35 IF (IHT .EQ. 1)   GO TO 50
      ISONDE = 5
      NNRAD = NRAD-1
      I[illegible](ITIME-ISONDE)  40,50,50
C
C     SET AM RADIOSONDE CURVE.
C
   40 DO 45  L=1,NRAD
      RADIO(L,1) = ARADIO(L,1)
   45 RADIO(L,2) = ARADIO(L,2)
      GO TO 60
C
C     SET PM RADIOSONDE CURVE.
C
   50 DO 55  L=1,NRAD
      RADIO(L,1) = PRADIO(L,1)
   55 RADIO(L,2) = PRADIO(L,2)
      ISONDE = 100
   60 DO 65  L=2,NRAD
   65 RSLOPE(L-1) = (RADIO(L,2)-RADIO(L-1,2))/(RADIO(L,1)-RADIO(L-1,1))
      GO TO 75
C
C     BARRIER CHECK POINT AGAINST ALL STATIONS.
C
   75 CALL BARIER (X,Y,WPOS,JBAR,NSTA)
      IF (ITIME-ISONDE) 100,80,80
C
C     SET PM RADIOSONDE CURVE.
C
   80 DO 85  K=1,NRAD
      RADIO(K,1) = PRADIO(K,1)
   85 RADIO(K,2) = PRADIO(K,2)
      ISONDE = 100
      DO 90  L=2,NRAD
   90 RSLOPE(L-1) = (RADIO(L,2)-RADIO(L-1,2))/(RADIO(L,1)-RADIO(L-1,1))
C
C     DETERMINE DISTANCES TO ALL USABLE POINTS.
C
  100 DO 120  I=1,NSTA
      IF (JBAR(I) .NE. 1)   GO TO 120
      GO TO 115
  115 NPTS = 1
      DIST(I) = (X-WPOS(I,1))**2 + (Y-WPOS(I,2))**2
      IF (DIST(I) .NE. 0.)   GO TO 120
```

```
C
C     INTERPOLATION POINT ON A STATION.
C
      IONE = I
      GO TO 250
  120 CONTINUE
C
C     NO STATIONS QUALIFY.
C
      IF (NPTS .EQ. 0)    RETURN
C
C     SUM CONTRIBUTIONS OF EACH STATION DIVIDED BY ITS DISTANCE TO THE
C          INTERPOLATED POINT SQUARED. DIVIDE RESULTS BY 1 OVER THE
C          SUM OF THE INVERSE DISTANCES. SET RESULTS INTO 'ANS'.
C
      DO 140  J=1,4
      DO 130  I=1,NSTA
      IF (JBAR(I) .NE. 1)   GO TO 130
      IF (AIR(ITIME+1,I,J) .EQ. 0.)   GO TO 130
      DISINV(J) = DISINV(J) + 1./DIST(I)
      VAL2(J) = VAL2(J)+AIR(ITIME+1,I,J)/DIST(I)
  130 CONTINUE
      IF (DISINV(J) .NE. 0)   GO TO 135
      VAL2(J) = 0.
      GO TO 140
  135 VAL2(J) = VAL2(J)/DISINV(J)
  140 CONTINUE
      DO 145  I=1,8
  145 DISINV(I) = 0.
      DO 160  J=1,4
      DO 150  I=1,NSTA
      IF (JBAR(I) .NE. 1)   GO TO 150
      IF (AIR(ITIME,I,J) .EQ. 0.)  GO TO 150
      DISINV(J) = DISINV(J) + 1./DIST(I)
      VAL1(J) = VAL1(J)+AIR(ITIME,I,J)/DIST(I)
  150 CONTINUE
      IF (DISINV(J) .NE. 0)    GO TO 155
      VAL1(J) = 0.
      GO TO 160
  155 VAL1(J) = VAL1(J)/DISINV(J)
  160 CONTINUE
      DO 170  J=1,4
  170 ANS(J) = VAL1(J)+(VAL2(J)-VAL1(J))*TIMEHR
      GO TO 190
C
C     SET GROUND ELEVATION
C
  190 DO 200  I=1,NSTA
      IF (JBAR(I) .NE. 1)     GO TO 200
      ANS(7) = ANS(7)+WPOS(I,3)/DIST(I)
      DISINV(7) = DISINV(7) + 1./DIST(I)
  200 CONTINUE
      HT = ANS(7)/DISINV(7)
      ANS(1) = ANS(1)/60.
      ANS(2) = ANS(2)/60.
      GO TO 400
C
C     TRAJECTORY POINT ON STATION.  SET ANS TO STATION VALUES.
C
C
  250 DO 270  J=1,6
      VAL2(J) = AIR(ITIME+1,IONE,J)
      VAL1(J) = AIR(ITIME,IONE,J)
  270 ANS(J) = VAL1(J)+(VAL2(J)-VAL1(J))*TIMEHR
      HT = WPOS(IONE,3)
C
C
C
C
C
C     DETERMINE MIXING HEIGHT AND MIXING HEIGHT DERIVATIVE.
C
  400 XDEPRV = XDEPTH
      XPREV = XTIME1
      IF (IHT .EQ. 1)     GO TO 480
      DO 420  I=1,NNRAD
      XHT = (ANS(3)-RADIO(I,2)+RSLOPE(I)*RADIO(I,1)-SLOPE*HT)/
     1      (RSLOPE(I)-SLOPE)
      IF ((XHT .GT. RADIO(I,1))    .AND.
     1    (XHT .LE. RADIO(I+1,1)) .AND.
     2    (XHT .GE. HT))           GO TO 450
  420 CONTINUE
      TMIN = 100.
      DO 425  I=1,NRAD
      IF ((HT .GT. RADIO(I,1)) .OR. (RADIO(I,2) .GE. TMIN))   GO TO 425
      TMIN = RADIO(I,2)
      HMIN = RADIO(I,1)
  425 CONTINUE
      IF ((TEMP+SLOPE*(HMIN-HT)) .GE. TMIN)    GO TO 450
  430 XDEPTH = AMAX1(XMIN,XDEPRV)
      XHT = XDEPTH+HT
      GO TO 500
  450 XDEPTH = XHT-HT
      XDEPTH = AMAX1(XMIN,XDEPTH)
      XHT = HT+XDEPTH
      GO TO 500
  480 XHT = XHITE(ITIME)
      XDEPTH = XHT-HT
  500 IDM = 1
      XTIME1 = XTIME
C
C
      XXDOT = ANS(1)
      YYDOT = ANS(2)
  620 RETURN
      END
```

```
                                 OS/360  FORTRAN H

COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=55,SIZE=0000K,
                   SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
      SUBROUTINE ULTRAV (RATE)                                          01571000
C                                                                       01572000
C                     ULTRAVIOLET RADIATION MODULE                      01573000
      COMMON /MYCOM/ TIME,ICLOUD,IOM,IDU,IDD,IDS,IPST,NSTA,NSTACK,NRAD, 01574000
     1        AIR(12,32,6),WPOS(32,3),POS(32,3),SPOS(32,3),HS(12),      01575000
     2        DS(12),VS(12),TS(12),QS(12),SBAROM,STEMP,XDOT,YDOT,       01576000
     3        ARADIO(15,2),PRADIO(15,2),ZENITH(12,2),SGRID(650),        01577000
     4        FGRID(650),AGRID1(650),AGRID2(650),AGRID4(650),EMIT(10),  01578000
     5        XHITE(12),IHT,XMIN                                        01579000
C                                                                       01580000
      DOUBLE PRECISION POLL                                             01580200
      COMMON /ALLCOM/ POLL(4,3),GPOLL(4,3),ANS(8),GUTIME,XDEPTH,ISOUR,  01581000
     1                XDEPRV                                            01581200
      EQUIVALENCE (TEMP,ANS(3)),(HUMID,ANS(4)),(BAROM,ANS(5)),          01582000
     1            (COVER,ANS(6)),(HT,ANS(7)),(XHT,ANS(8))               01583000
C                                                                       01584000
C     DECLARE ARRAYS AND PRESET DATA                                    01585000
C     ABSORP--11 VALUES OF ABSORPTION COEFFICIENTS OF NO2 AND N2O4      01586000
C     AIRMS---12 VALUES OF THE AIR MASS AT VARIOUS ZENITH ANGLES        01587000
C     CLOUD---4 AVERAGE FRACTIONS OF INCIDENT RADIATION TRANSMITTED BY  01588000
C           7 CLOUD TYPES                                               01589000
C     OZONE---11 ABSORPTION COEFFICIENTS OF OZONE IN THE ULTRAVIOLET    01590000
C           REGION BY WAVELENGTH, 3000A-4000A                           01591000
C     SOLAR---11 MEAN SOLAR SPECTRAL IRRADIANCE OUTSIDE THE ATMOSPHERE  01592000
C           FOR SPECTRAL BANDWIDTHS OF 100A CENTERED AT WAVELENGTHS     01593000
C           3000A-4000A                                                 01594000
C     XMOLE---11 INDICES OF REFRACTION AND MOLECULAR SCATTERING COEFFI- 01595000
C           CIENTS FOR A HOMOGENEOUS STANDARD ATMOSPHERE AT 3000A-4000A 01596000
C     ZENITH--13 VALUES OF TIME OF DAY AND ANGLE OF SUN TO VERTICAL     01597000
C     VAPOR---VALUES OF WATER VAPOR PRESSURE FOR DIFFERENT TEMPERATURES 01598000
C     XLIST---INDEPENDENT VARIABLE INTERPOLATION LIST                   01599000
C     FLIST---DEPENDENT VARIABLE LIST CORRESPONDING TO INDEPENDENT      01600000
C           VALUES IN FLIST                                             01601000
C                                                                       01602000
      DIMENSION AIRMS(9,2),CLOUD(4,8),OZONE(11),SOLAR(11),XMOLE(11),    01603000
     1    VAPOR(9,2),ABSORP(11),                                        01604000
     2    XLISTZ(50),XLISTA(50),XLISTC(50),XLISTV(50),                  01605000
     3    FLISTZ(50),FLISTA(50),FLISTC(50),FLISTV(50)                   01606000
C                                                                       01607000
C     DECLARE PRESET CONSTANTS                                          01608000
C                                                                       01609000
C     DUST   == DUST CONTENT OF ATMOSPHERE                              01610000
C     OZ3    == OZONE CONTENT OF ATMOSPHERE                             01611000
C     G      == REFLECTION COEFFICIENT                                  01612000
C     ALBEDO == FRACTION OF                                             01613000
C     PI     == 3.14159                                                 01614000
C                                                                       01615000
C     TIME          TIME OF DAY                                         01616000
C     TEMP          HOURLY TEMPERATURE OF THREE CLOSEST WEATHER STATIONS 01617000
C     BAROM         HOURLY BAROMETRIC PRESSURE OF 3 CLOSEST WEATHER STAS 01618000
C     HUMID         HOURLY HUMIDITY OF THREE CLOSEST WEATHER STAS (PERCT) 01619000
```

```
C     COVER        HOURLY CLOUD COVER OF THE 3 CLOSEST WEATHER STATIONS
C     XHT         CALCULATED MIXING HEIGHT (M)
C     ZZ          INTERPOLATED ELEVATION AT BASE OF COLUMN (M)
C     TEMPD        RATE OF CHANGE OF TEMPERATURE
C     BAROMD                         BAROMETER
C     XHTD                           MIXING HEIGHT
C
      DOUBLE PRECISION RATE
      DATA  ALBEDO /0.0/
      DATA  DUST  /1.0/
      DATA  G  /0.5/
      DATA  OZ3  /2.2/
      DATA  PI  /3.14159/
C
      DATA
     &     ABSORP/37.,57.,78.,98.,119.,136.,149.,158.,163.,167.,171./,
     1     AIRMS/15.,20.,30.,40.,45.,60.,70.,80.,85 ,1.03,1.06,1.15,
     2          1.30,1.41,2.00,2.90,5.60,10.39/,
     3     CLOUD/1.1,2.0,3.0,4.0,.85,.89,.82,.80,.84,.78,.71,.65,.52,
     4          .50,.47,.45,.41,.41,.41,.41,.35,.34,.32,.31,.25,.25,
     5          .24,.24,.17,.17,.18,.18/,
     1     OZONE/.44,.12,.032,.0085,.0020,.0005,5*0 /,
     &     SOLAR/.92,1.19,1.37,1.91,1.90,2.07,2.10,2.48,2.36,2.20,
     &          3.10/,
     5     XMOLE/.530,.461,.402,.353,.311,.275,.245,.218,.195,.175,
     1          .158/,
     &     VAPOR/0.,5.,10.,15.,20.,25.,30.,35.,40.,.4579,.6543,.9209,
     3          1.2788,1.7535,2.3756,3.1824,4.2175,5.5324/
C
C
C
C     CHECK FOR FIRST TIME THROUGH ULTRAV
C
      IF (IDU .EQ. 1)  GO TO 250
C     SET UP ARRAY ZENITH FOR INTERPOLATION (XLISTZ,FLISTZ)
C     SET UP ARRAY AIRMS FOR INTERPOLATION (XLISTA,FLISTA)
C     SET UP ARRAY CLOUD FOR INTERPOLATION (XLISTC,FLISTC)
C     SET UP ARRAY VAPOR FOR INTERPOLATION (XLISTV,FLISTV)
C
      DO 50 I=1,12
      XLISTZ(I) = ZENITH(I,1)
   50 FLISTZ(I) = ZENITH(I,2)
      DO 100  I=1,9
      XLISTA(I) = AIRMS(I,1)
  100 FLISTA(I) = AIRMS(I,2)
      DO 150 I=1,4
      XLISTC(I) = CLOUD(I,1)
  150 FLISTC(I) = CLOUD(I,ICLOUD)
      DO 200  I=1,9
      XLISTV(I) = VAPOR(I,1)
  200 FLISTV(I) = VAPOR(I,2)
      IDU = 1
C
```

```
C     DETERMINE ANGLE OF SUN
C                   AIR MASS AT THIS ZENITH ANGLE
C                   BETA (INCIDENT RADIATION) FOR THIS MASS AND A CLOUD TYPE
C                   PARTIAL PRESSURE OF WATER VAPOR IN THE ATMOSPHERE
C
  250 ANGLE = PIF2(TIME,XLISTZ,12,FLISTZ)
      CANGLE = COS(ANGLE*PI/180.)
      AIRMAS = PIF2(ANGLE,XLISTA,9,FLISTA)
      BETA = PIF2(AIRMAS,XLISTC,4,FLISTC)
      PRESS = PIF2(TEMP,XLISTV,9,FLISTV)
      PZ = PRESS*HUMID
      W = 2.3*PZ*10.**(-HT/22000.)
      C1 = (1.-COVER)/CANGLE+2.0*BETA*COVER
      C2 = 2.0*(1.-COVER+BETA*COVER)
C
C
C     FOR EACH WAVELENGTH IN ANGSTROMS FROM 3000 TO 4000 (BY HUNDREDS),
C     DETERMINE THE FOLOWING VALUES
C             A   MOLECULAR SCATTERING COEFFICIENT (TABLE XMOLE)
C             B   TRANSMISSION DUE TO MOLECULAR SCATTERING
C             C   TRANSMISSION DUE TO PARTICLE SCATTERING
C             D   ABSORPTION COEFFICIENT OF OZONE (TABLE OZONE)
C             E   TRANSMISSION DUE TO OZONE
C             F   MEAN SOLAR SPECTRAL IRRADIANCE OUTSIDE THE ATMOSPHERE
C                 (TABLE SOLAR)
C             G   DIRECT AND SKY RADIATION
C             H   CONTRIBUTION TO ULTRA VIOLET REACTANT RATE PARAMETER
C                 FOR ONE WAVELENGTH
C     THEN SUM THE CONTRIBUTION TO GET THE SPECIFIC ABSORPTION RATE
C
C
      L = 1
      RATE1 = 0.
      RATE2 = 0.
      RATE  = 0.
      DO 300 LAMDA=3000,3800,100
C
C     A,B
      SCTMOL = -XMOLE(L)*BAROM*AIRMAS/1013.25
C
C     C
      XLAMD4 = 1.E+04/LAMDA
      SCTPAR = -(3.75E-03*W*XLAMD4*XLAMD4 +
     .          3.5E-02*DUST*XLAMD4**.75) *AIRMAS
C
C     D,E
      SCATOZ = -OZONE(L)*OZ3*AIRMAS
C     F,G
      DIRECT = 10.**(SCTMOL+SCTPAR+SCATOZ)*SOLAR(L)*CANGLE
      SKY = G*(1.-10.**(SCTMOL+SCTPAR))*10.**SCATOZ*SOLAR(L)*CANGLE
C
C     H
      RATE1 = RATE1+ABSORP(L)*DIRECT
      RATE2 = RATE2+ABSORP(L)*SKY
  300 L = L+1
      RATE = 2.303*6.0/(6.03E+04)*(1.+ALBEDO)*(C1*RATE1+C2*RATE2)
      RETURN
      END
```

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                                           OS/360  FORTRAN H

COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=55,SIZE=0000K,
                   SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
            SUBROUTINE SOURCE(X,Y)                                              01731000
      C                                                                         01732000
      C                         SOURCE EMISSIONS MODULE                         01733000
      C                                                                         01734000
            COMMON /MYCOM/ TIME,ICLOUD,IDM,IDU,IDD,IDS,IPST,NSTA,NSTACK,NRAD,   01735000
           1          AIR(12,32,6),WPOS(32,3),POS(32,3),SPOS(32,3),HS(12),      01736000
           2          DS(12),VS(12),TS(12),QS(12),SBAROM,STEMP,XDOT,YDOT,       01737000
           3          ARADIO(15,2),PRADIO(15,2),ZENITH(12,2),SGRID(650),        01738000
           4          FGRID(650),AGRID1(650),AGRID2(650),AGRID4(650),EMIT(10),  01739000
           5          XHITE(12),IHT,XMIN                                        01740000
      C                                                                         01741000
            DOUBLE PRECISION POLL                                               01741200
            COMMON /ALLCOM/ POLL(4,3),GPOLL(4,3),ANS(8),GOTIME,XDEPTH,ISOUR,    01742000
           1                XDEPRV                                              01742200
      C                                                                         01743000
      C     DECLARE ARRAYS AND PRESET DATA                                      01744000
      C     POLL----ARRAY OF 4 POLLUTANTS, 3 SOURCES                            01745000
      C     EMIT----EMISSION RATES OF POLLUTANTS                                01746000
      C     WEIGHT--GRAM MOLECULAR WEIGHTS OF POLLUTANTS                        01747000
      C     FCURVE--TEMPORAL DISTRIBUTION CURVE OF FREEWAY TRAFFIC              01748000
      C     SCURVE--TEMPORAL DISTRIBUTION CURVE OF STREET TRAFFIC               01749000
      C     IBOX----INDEX TO GRID POPULATION ARRAYS                             01750000
      C     EPOS----MIDPOINTS OF ADJACENT GRIDS TO TRAJECTORY POINT             01751000
      C     FGRID---FREEWAY MILEAGE DISTRIBUTION BY GRID                        01752000
      C     SGRID---STREET MILEAGE DISTRIBUTION BY GRID                         01753000
      C     AGRID---AREA SOURCES USAGE DISTRIBUTION BY GRID                     01754000
      C                                                                         01755000
            DIMENSION WEIGHT(10),FCURVE(26),SCURVE(26),ACURVE(26),IBOX(4),      01756000
           1          EPOS(4,2),DIST(4),EMITWT(10)                              01757000
      C                                                                         01758000
      C     ORDER OF MOLECULAR WEIGHTS--PROPYLENE,NO,CO,DUMHC                   01759000
      C                                                                         01760000
            DATA WEIGHT /42.,30.,28.,25.,6*0./                                  01761000
      C                                                                         01762000
            DATA FCURVE /.03022,5*.00776,.0178,.0591,.0768,.0648,.0536,         01763000
           1            4*.049425,.0569,3*.0746,.0598,5*.03022,.00776/          01764000
      C                                                                         01765000
            DATA SCURVE /.030775,6*.006783,.0293,2*.0651,2*.0502,5*.06088,      01766000
           1            2*.08195,2*.05405,4*.030775,.006783/                    01767000
      C                                                                         01768000
      C     IF STANDARD TIME, DON'T RESET                                       01769000
      C                                                                         01770000
            IF (IPST .EQ. 1)  GO TO 20                                          01771000
            TIME = TIME+1.0                                                     01772000
      C                                                                         01773000
      C     CHECK FOR FIRST TIME THRU ROUTINE                                   01774000
      C                                                                         01775000
         20 IF (IDS .EQ. 1)  GO TO 50                                           01776000
            AX = .0833                                                          01777000
            POLL(3,3) = 0.                                                      01778000
            DO 40 I=1,4                                                         01779000
```

```
   40 EMITWT(I) = EMIT(I)/(WEIGHT(I)*60.)
      IDS = 1
   50 IHR = TIME+2.0
      GMIN = TIME+2.0-IHR
C
C     EVALUATE TEMPORAL DISTRIBUTION CURVES
C
      IF (GMIN .GT. 0.5)  GO TO 100
      FX = FCURVE(IHR-1)*(.5-GMIN) + FCURVE(IHR)*(.5+GMIN)
      SX = SCURVE(IHR-1)*(.5-GMIN) + SCURVE(IHR)*(.5+GMIN)
      GO TO 150
  100 FX = FCURVE(IHR)*(1.5-GMIN) + FCURVE(IHR+1)*(GMIN-0.5)
      SX = SCURVE(IHR)*(1.5-GMIN) + SCURVE(IHR+1)*(GMIN-0.5)
C
C     DETERMINE TRAJECTORY GRID EMISSION INDEX AND GRID MIDPOINT
C
  150 IX = (X+1)/2
      IY = (Y+1)/2-1
      IBOX(1) = IX+25*IY-8
      IXM = (X-1)/2
      IXM = 2*(IXM+1)
      IYM = (Y-1)/2
      IYM = 2*(IYM+1)
C
C     FIND QUADRANT OF GRID CONTAINING TRAJECTORY POINT
C     SET EMISSION INDICES FOR ADJACENT GRIDS
C
      IF (X .GE. IXM)  GO TO 200
      IF (Y .GE. IYM)  GO TO 250
C
C     X NEGATIVE, Y NEGATIVE
C
      IBOX(2) = IBOX(1)-25
      IBOX(3) = IBOX(1)-26
      IBOX(4) = IBOX(1)-1
      IPT = 1
      GO TO 400
  200 IF (Y .GE. IYM)  GO TO 300
C
C     X POSITIVE, Y NEGATIVE
C
      IBOX(2) = IBOX(1)-25
      IBOX(3) = IBOX(1)-24
      IBOX(4) = IBOX(1)+1
      IPT = 2
      GO TO 400
C
C     X NEGATIVE, Y POSITIVE
C
  250 IBOX(2) = IBOX(1)+25
      IBOX(3) = IBOX(1)+24
      IBOX(4) = IBOX(1)-1
      IPT = 3
      GO TO 400
C
C     X POSITIVE, Y POSITIVE
C
  300 IBOX(2) = IBOX(1)+25
      IBOX(3) = IBOX(1)+26
      IBOX(4) = IBOX(1)+1
      IPT = 4
C
C
C
C
C
C
C
C
C
C
C     SET MIDPOINTS OF ADJACENT GRIDS
C
  400 GO TO (420,440,460,480),IPT
  420 EPOS(2,2) = IYM-2
      EPOS(3,1) = IXM-2
      GO TO 500
  440 EPOS(2,2) = IYM-2
      EPOS(3,1) = IXM+2
      GO TO 500
  460 EPOS(2,2) = IYM+2
      EPOS(3,1) = IXM-2
      GO TO 500
  480 EPOS(2,2) = IYM+2
      EPOS(3,1) = IXM+2
  500 EPOS(2,1) = IXM
      EPOS(3,2) = EPOS(2,2)
      EPOS(4,1) = EPOS(3,1)
      EPOS(4,2) = IYM
C
C     CALCULATE EMISSION CONTRIBUTIONS TO THE COLUMN OF THE FOUR
C          ADJACENT GRIDS INVERSELY PROPORTIONAL TO THE SQUARE OF
C          THE DISTANCE FROM THE TRAJECTORY POINT TO THE GRID MIDPTS.
C
      DIST(1) = (X-IXM)**2 + (Y-IYM)**2
      IF (DIST(1) .EQ. 0.)  GO TO 600
      DISINV = 1/DIST(1)
      STREET = SGRID(IBOX(1))/DIST(1)
      FWY    = FGRID(IBOX(1))/DIST(1)
      IF (ISOUR .NE. 1)  GO TO 540
      AREA1  = AGRID1(IBOX(1))/DIST(1)
      AREA2  = AGRID2(IBOX(1))/DIST(1)
      AREA4  = AGRID4(IBOX(1))/DIST(1)
  540 DO 550  I=2,4
      IF (IBOX(I) .EQ. 0)  GO TO 550
      DIST(I) = (X-EPOS(I,1))**2 + (Y-EPOS(I,2))**2
      DISINV = DISINV+1/DIST(I)
      STREET = STREET + SGRID(IBOX(I))/DIST(I)
      FWY    = FWY    + FGRID(IBOX(I))/DIST(I)
      IF (ISOUR .NE. 1)  GO TO 550
      AREA1  = AREA1  + AGRID1(IBOX(I))/DIST(I)
      AREA2  = AREA2  + AGRID2(IBOX(I))/DIST(I)
      AREA4  = AREA4  + AGRID4(IBOX(I))/DIST(I)
  550 CONTINUE
      STREET = STREET/DISINV
      FWY    = FWY/DISINV
      IF (ISOUR .NE. 1)  GO TO 620
      AREA1  = AREA1/DISINV
      AREA2  = AREA2/DISINV
      AREA4  = AREA4/DISINV
      GO TO 620
C
C     TRAJECTORY ON MIDPOINT OF GRID
C
  600 STREET = SGRID(IBOX(1))
      FWY    = FGRID(IBOX(1))
      IF (ISOUR .NE. 1)  GO TO 620
      AREA1  = AGRID1(IBOX(1))
      AREA2  = AGRID2(IBOX(1))
      AREA4  = AGRID4(IBOX(1))
C
C     CALCULATE EMISSIONS FROM SOURCES
C
  620 STTEMP = SX*STREET/10359386.
      FTEMP = FX*FWY/10359386.
      IF (ISOUR .NE. 1)  GO TO 640
      ATEMP1 = AX*AREA1/10359386.
      ATEMP2 = AX*AREA2/10359386.
      ATEMP4 = AX*AREA4/10359386.
  640 FACTOR = 4.0E6/XDEPTH
      DO 650  I=1,4
      GPOLL(I,1) = STTEMP*EMITWT(I)
      GPOLL(I,2) = FTEMP*EMITWT(I)
      POLL(I,1) = GPOLL(I,1)*FACTOR
  650 POLL(I,2) = GPOLL(I,2)*FACTOR
      IF (ISOUR .NE. 1)  GO TO 680
      GPOLL(1,3) = ATEMP1*EMITWT(1)
      GPOLL(2,3) = ATEMP2*EMITWT(2)
      GPOLL(4,3) = ATEMP4*EMITWT(4)
      POLL(1,3)  = GPOLL(1,3)*FACTOR
      POLL(2,3)  = GPOLL(2,3)*FACTOR
      POLL(4,3)  = GPOLL(4,3)*FACTOR
  680 IF (IPST .EQ. 1)  GO TO 700
      TIME = TIME-1.0
  700 RETURN
      END
```

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                                   OS/360  FORTRAN H

COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=55,SIZE=0000K,
                   SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
            FUNCTION PIF2 (X,XLIST,N,FLIST)                                   01930000
      C                                                                       01931000
      C     SECOND ORDER ONE VARIABLE INTERPOLATION                           01932000
      C                                                                       01933000
            DIMENSION XLIST(100), FLIST(100)                                  01934000
            BLI(FL0,FL1,FL2,FL3,FL4) = ((FL1-FL0)*(FL3-FL4)/(FL2-FL1)+FL3)    01935000
            IF (X-XLIST(N)) 2,1,1                                             01936000
      C                                                                       01937000
      C     PAST END OF INDEPENDENT VARIABLE LIST.                            01938000
      C                                                                       01939000
          1 I = N-1                                                           01940000
            GO TO 5                                                           01941000
          2 IF (X-XLIST(1)) 4,4,6                                             01942000
      C                                                                       01943000
      C     BEFORE START OF INDENDENT VARIABLE LIST.                          01944000
      C                                                                       01945000
          4 I = 1                                                             01946000
          5 K = 1                                                             01947000
            GO TO 30                                                          01948000
          6 K = 2                                                             01949000
      C                                                                       01950000
      C     DETERMINE INDEPENDENT VARIABLE INTERVAL.                          01951000
      C                                                                       01952000
          7 DO 8 I=1,N                                                        01953000
            IF (X-XLIST(I)) 9,9,8                                             01954000
          8 CONTINUE                                                          01955000
            I = N                                                             01956000
          9 I = I-1                                                           01957000
         30 BLIF1 = BLI(X,XLIST(I),XLIST(I+1),FLIST(I),FLIST(I+1))            01958000
         10 IF (K-1) 11,11,12                                                 01959000
         11 PIF2 = BLIF1                                                      01960000
            RETURN                                                            01961000
      C                                                                       01962000
      C     FIND BEST THIRD POINT.                                            01963000
      C                                                                       01964000
         12 IF ((I+2)-N) 13,13,16                                             01965000
         13 IF((I-1)-1) 15,14,14                                              01966000
         14 IF(ABS(XLIST(I-1)-X) - ABS(XLIST(I+2)-X)) 16,15,15                01967000
         15 L = I+2                                                           01968000
            GO TO 17                                                          01969000
         16 L = I-1                                                           01970000
       17   BLIF2 = (BLI(X,XLIST(I),XLIST(L),FLIST(I),FLIST(L)))              01971000
            PIF2 = BLI(X,XLIST(I+1),XLIST(L),BLIF1,BLIF2)                     01972000
         18 RETURN                                                            01973000
            END                                                               01974000
```

```
COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=55,SIZE=0000K,
                   SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
            SUBROUTINE BARIER (X,Y,WPOS,JBAR,NPOS)
      C
      C     DETERMINES IF INTERSECTION OF LINE SEGMENT CONNECTING TRAJECTORY
      C     POINT AND STATION AND THE BARRIER LINE SEGMENT LIES ON THE BARRIER
      C     ITSELF.  EVALUATE FUNCTIONS ALPHA AND BETA.  IF THEY ARE BOTH LESS
      C     THAN 1 AND GREATER THAN 0, STATION IS ELIMINATED.
            COMMON  /BARRR/ IDB
      C
            DIMENSION WPOS(32,3),JBAR(32),BAR(10,10),BSLOPE(10,10),
           1          TSLOPE(32,2)
      C
      C     NBAR IS NUMBER OF BARRIERS
      C      ARRAY BAR---ODD COLUMNS CONTAIN X COORDINATES
      C                  EVEN COLUMNS CONTAIN Y COORDINATES
      C                  ROW 1 IN ODD COLUMNS CONTAIN NO. OF POINTS IN BARRIER
      C      ARRAY BSLOPE--ODD COLUMNS CONTAIN M VALUES OF BARRIER LINE SEGMTS
      C                  EVEN COLUMNS CONTAIN Y VALUES OF BARRIER LINE SEGMENTS
      C      ARRAY TSLOPE--ODD COLUMN CONTAINS M VALUES OF TRAJECTORY POINT
      C                       WEATHER STATION LINE SEGMENT
      C                  EVEN COLUMN CONTAINS B VALUES OF TRAJECTORY POINT
      C                       WEATHER STATION LINE SEGMENT
      C
            DATA NBAR/ 2/, BAR/2.,16.,38.,8*0.,2*40.,7*0.,4.,53.,62.,66.,71.,
           1          6*0.,31.,27.,32.,23.,65*0./
      C
      C     DETERMINE SLOPE AND INTERCEPT FROM INTERPOLATION POINT TO EACH
      C          STATION.
      C
            DO 50  I=1,NPOS
            TSLOPE(I,1) = 0.
       50   TSLOPE(I,2) = 0.
            DO 100  I=1,NPOS
            IF((WPOS(I,1)-X) .EQ. 0.)  GO TO 100
            TSLOPE(I,1) = (WPOS(I,2)-Y)/(WPOS(I,1)-X)
            TSLOPE(I,2) = Y-TSLOPE(I,1)*X
      100   CONTINUE
      C
      C     DETERMINE SLOPE AND INTERCEPT OF EACH SEGMENT OF EACH BARRIER
      C
            IF (IDB .EQ. 1)   GO TO 210
            DO 200  J=1,NBAR
            NNBAR = BAR(1,2*J-1)
            DO 200  K=2,NNBAR
            IF ((BAR(K+1,2*J-1)-BAR(K,2*J-1)) .EQ. 0.)  GO TO 200
            BSLOPE(K,2*J-1) = (BAR(K+1,2*J)-BAR(K,2*J))/
           1                        (BAR(K+1,2*J-1)-BAR(K,2*J-1))
            BSLOPE(K,2*J) = BAR(K,2*J)-BSLOPE(K,2*J-1)*BAR(K,2*J-1)
      200   CONTINUE
            IDB = 1
      C
      C     DETERMINE INTERSECTION FUNCTIONS
```

```
C          IF VALUE OF INSECTION IS LE TO ZERO OR GE 1,
C          INCLUDE STATION.
C
  210 DO 400  I=1,NPOS
      DO 375  J=1,NBAR
      NNBAR = BAR(1,2*J-1)
      DO 375  K=2,NNBAR
      IF ((BAR(K+1,2*J-1)-BAR(K,2*J-1)) .EQ. 0.)  GO TO 220
      DENOM1 = BSLOPE(K,2*J-1)*(X-WPOS(I,1))-(Y-WPOS(I,2))
      IF (DENOM1 .EQ. 0.)   GO TO 350
      ALPHA = (WPOS(I,2)-BSLOPE(K,2*J-1)*WPOS(I,1)-BSLOPE(K,2*J))/
     &            DENOM1
      GO TO 240
  220 DENOM2 = X-WPOS(I,1)
      IF (DENOM2 .EQ. 0.)   GO TO 350
      ALPHA = -WPOS(I,1)/DENOM2
  240 IF (ALPHA .GE. 1.)  GO TO 350
      IF (ALPHA .LE. 0.)  GO TO 350
      IF ((WPOS(I,1)-X) .NE. 0.)  GO TO 250
      IF ((WPOS(I,2)-Y) .EQ. 0.)  GO TO 350
      GO TO 260
  250 DENOM3 = TSLOPE(I,1)*(BAR(K,2*J-1)-BAR(K+1,2*J-1))
     &            -BAR(K,2*J)+BAR(K+1,2*J)
      IF (DENOM3 .EQ. 0.)    GO TO 350
      BETA = (BAR(K+1,2*J)-TSLOPE(I,1)*BAR(K+1,2*J-1)-TSLOPE(I,2))/
     &            DENOM3
      GO TO 280
  260 DENOM4 = BAR(K,2*J-1)-BAR(K+1,2*J-1)
      IF (DENOM4 .EQ. 0.)   GO TO 350
      BETA = -BAR(K+1,2*J-1)/DENOM4
  280 IF (BETA .GE. 1.)  GO TO 350
      IF (BETA .LE. 0.)  GO TO 350
      JBAR(I) = 0
      GO TO 400
  350 JBAR(I) = 1
  375 CONTINUE
  400 CONTINUE
      RETURN
      END
```

```
                                      OS/360  FORTRAN H

COMPILER OPTIONS - NAME=  MAIN,OPT=01,LINECNT=55,SIZE=0000K,
                   SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
      SUBROUTINE SMGPLT
      DIMENSION OUT(101),YPR(11)                                        02065000
      DOUBLE PRECISION C,D,Z,DERY,ZZ,PRMT,BB,POLL,YY                    02066000
      COMMON /KINCOM/ ZZ(4),YY(40),LABEL(40),D(50),PCT(50,3),PRMT(8),   02067000
     1      DERY(40),C(50),BB,Z(2),N,NC,NEQ,NDIF,KDIF,M,NN,INTR,NNC,    02068000
     2      NNDIF,IUV,IM,IS,ITRAF,NLL,CC(16,100),A(80),STEP(15),TIM1,   02069000
     3      TIM2,TIM4,PEAK1,TIME1,PEAK3,TIME3,XPOS,YPOS                 02070000
C                                                                       02071000
      COMMON /ALLCOM/ POLL(4,3),GPOLL(4,3),ANS(8),GCTIME,XDEPTH,ISOUR,  02072000
     1                XDEPRV                                            02073000
      REAL*8 LABEL, RCT                                                 02073200
      REAL   BLANK/' '/,ANG(16)/'X','1','2','3','4','5','6','7','8','9',02074000
     2'A','B','C','D','E','F'/,IB/'I'/                                  02075000
      YMIN = 0.                                                         02076000
      DO 5  I=1,101                                                     02077000
    5 OUT(I) = 0.                                                       02078000
      DO 6  I=1,11                                                      02079000
    6 YPR(I) = 0.                                                       02080000
      MM=NDIF+1                                                         02081000
      NN=NN-1                                                           02082000
      WRITE(6, 9) NDIF,NN                                               02083000
      IF(CC(2,NN).NE.PEAK1.AND.CC(3,NN).NE.PEAK3) GO TO 10              02084000
      WRITE (6,115)                                                     02085000
   10 WRITE (6,110) PEAK1,TIME1,PEAK3,TIME3                             02086000
      IF(TIM1.NE.0.0) WRITE (6,120) TIM1                                02087000
      IF(TIM2.NE.0.0) WRITE (6,130) TIM2                                02088000
      IF(TIM4.NE.0.0) WRITE (6,140) TIM4                                02089000
   11 NGRAPH=1                                                          02090000
      IF(MM-9) 15, 15, 12                                               02091000
   12 NGRAPH=2                                                          02092000
      IF (MM-14) 14,14,13                                               02093000
   13 NGRAPH=3                                                          02094000
   14 JMAX=6                                                            02095000
      GO TO 16                                                          02096000
   15 JMAX=MM                                                           02097000
   16 JMIN=2                                                            02098000
      IF(NLL) 18,18,20                                                  02099000
   18 NLL=51                                                            02100000
   20 IF(NLL.LT.NN)NLL=NN+1                                             02101000
      AA=NLL-1                                                          02102000
      XSCAL=(PRMT(2)-PRMT(8))/AA                                        02103000
      IF (PRMT(2) .GT. CC(1,NN)+5.0)  XSCAL=(CC(1,NN)-PRMT(8))/AA       02104000
      XSCLHF=XSCAL/2.0                                                  02105000
      DO 95 K=1,NGRAPH                                                  02106000
      IF(NGRAPH-K) 21,21,22                                             02107000
   21 JAX=MM                                                            02108000
      GO TO 23                                                          02109000
   22 JAX=K*5+1                                                         02110000
   23 JIN=(K-1)*5+2                                                     02111000
  125 YMAX=0.0                                                          02112000
      DO 40 I=1,NN                                                      02113000
                                                                        02114000
      DO 40 J=JMIN,JMAX                                                 02115000
      IF(CC(J,I)-YMAX) 40,40,30                                         02116000
   30 YMAX = CC(J,I)                                                    02117000
   40 CONTINUE                                                          02118000
      YSCAL=YMAX/100.                                                   02119000
      XB=CC(1,1)                                                        02120000
      L= 1                                                              02121000
      I=1                                                               02122000
      WRITE (6,1) PRMT(1),PRMT(7),PRMT(5),PRMT(6),A                     02123000
      WRITE (6,7)                                                       02124000
   45 F=I-1                                                             02125000
      XPR=XB + F* XSCAL                                                 02126000
   46 IF (XPR-CC(1,L)-1.0)  48,48,47                                    02127000
   47 L=L+1                                                             02128000
      GO TO 46                                                          02129000
   48 IF (CC(1,L)-XSCLHF-XPR)  50,50,70                                 02130000
   50 IF (L .GT. NN)  GO TO 70                                          02131000
      DO 55  IX=1,101                                                   02132000
   55 OUT(IX)=BLANK                                                     02133000
      OUT(1)=IB                                                         02134000
      OUT(101)=IB                                                       02135000
      DO 60 J=JIN,JAX                                                   02136000
      JP =((CC(J,L)-YMIN)/YSCAL) +1.5                                   02137000
      IF(JP) 60,60,56                                                   02138000
   56 IF(JP-101)57,57,60                                                02139000
   57 IF (OUT(JP).EQ.BLANK.OR.OUT(JP).EQ.IB) GO TO 59                   02140000
      OUT(JP)= ANG(1)                                                   02141000
      GO TO 60                                                          02142000
   59 OUT(JP) = ANG(J)                                                  02143000
   60 CONTINUE                                                          02144000
      WRITE(6,2) XPR,(OUT(IZ),IZ=1,101),CC(1,L)                         02145000
      L=L+1                                                             02146000
      GO TO 80                                                          02147000
   70 WRITE(6,3) XPR                                                    02148000
   80 I=I+1                                                             02149000
      IF (I-NLL)  45,45,86                                              02150000
   86 WRITE(6,7)                                                        02151000
      YPR(1)= YMIN                                                      02152000
      DO 90 KM=1,9                                                      02153000
   90 YPR(KM+1)= YPR(KM) +YSCAL*10.0                                    02154000
      YPR(11)=YMAX                                                      02155000
      WRITE(6,8)(YPR(IP),IP=1,11)                                       02156000
   95 CONTINUE                                                          02157000
      JMIN=JMAX+1                                                       02158000
      JMAX=MM                                                           02159000
      JIN=6                                                             02160000
      JAX=JMAX                                                          02161000
      IF(JMAX-JMIN) 99,99,125                                           02162000
   99 RETURN                                                            02163000
    1 FORMAT ('1',E10.4,' MIN SIMULATION  BB=',E10.4,'  PRMT(3)=',E10.4,02164000
     1'  PRMT(4)=',E10.4,/,4(' ',20A4,/))                               02165000
    2 FORMAT(1H ,F 8.1,2X,101A1,F7.2)                                   02166000
    3 FORMAT (1H ,F8.1,2X,'I',99X,'I')                                  02167000
    7 FORMAT(1H ,10X,10(10H*    .     ),1H*)                              02168000
    8 FORMAT(1H ,3X,11F10.2)                                              02169000
    9 FORMAT('OTHERE ARE',I3,' DIF. CONCN. AND',I3,' STEPS IN THIS SET 002170000
     1F DATA.',////)                                                      02171000
  100 FORMAT(' ','MM WAS CHANGED TO 10, NN WAS CHANGED TO 50.')           02172000
  110 FORMAT(' NO2 PEAK CONCN PPHM WAS ',E13.7,' AT TIME ',E9.3,' MIN,',02173000
     1/,      ' O3 PEAK CONCN PPHM WAS ',E13.7,' AT TIME ',E9.3,' MIN.')02174000
  115 FORMAT(1H ,'BOTH PEAK VALUES NOT REACHED, HIGHEST VALUES WERE')     02175000
  120 FORMAT('OHALF-TIME FOR NO2 IS ',F7.3,' MINUTES.')                   02176000
  130 FORMAT('OHALF-TIME FOR NO  IS ',F7.3,' MINUTES.')                   02177000
  140 FORMAT('OHALF-TIME FOR OLEFIN IS ',F7.3,' MINUTES.')                02178000
  150 FORMAT(1H1)                                                         02179000
      END                                                                 02180000
```

Section IX

Operation of the Reverse Trajectory Program

The reverse trajectory program calculates air parcel paths beginning with the terminal position. It uses hourly average wind information, and interpolates initial pollutant concentrations from hourly pollutant monitoring data. Starting values are computed for nitrogen dioxide, nitric oxide, ozone, and carbon monoxide. Trajectories may also be calculated in a forward direction with the pollutant interpolation occurring at the end point. In this case, the values computed for NO_2, NO, O_3 and CO amy be considered for validation purposes.

The program's operation, subroutine by subroutine follows:

1. MAIN

   a. Reads in all input data to the program.
   b. Converts all data to the metric system.
   c. Initialization function.
   d. Prints meteorological and pollutant data.
   e. Calls SMGDRV.
   f. Calls POLLUT.
   g. Outputs pollutant interpolation values.
   h. Checks for multiple runs.

2. SMGDRV

   a. Serves numerical integration function.
   b. Controls processing end time.
   c. Calls RWIND.
   d. Calls PUTOUT.

3. RWIND

   a. Calls BARIER.
   b. Determines wind velocity inputs for the particular trajectory point.

c. Determines wind velocity rates of change (derivatives) of wind velocity data.

4. BARIER

a. Determines if a natural barrier blocks a meteorological station or a pollutant monitoring station from the trajectory point in consideration. If so, the station is discounted.

5. PUTOUT

a. Prints trajectory positions, time into trajectory in minutes.

6. POLLUT

a. Calls BARIER

b. Determines interpolated concentrations of NO_2, NO, O_3, and CO at final trajectory point.

Section X

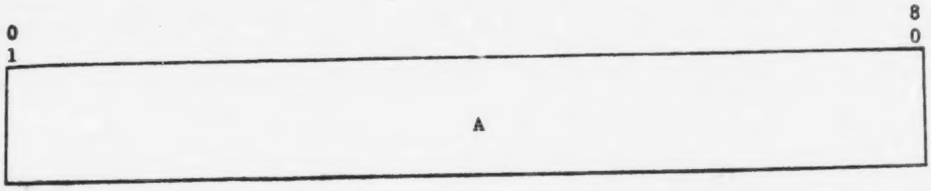
Reverse Trajectory Inputs

Inputs must be prepared exactly as described. A sample input deck is shown in Section X.

1. Card Type 1

Heading data---array A---4 cards

Alphanumeric data used as heading information. May be blank cards.



2. Card Type 2

Starting data--7 Items--1 Card

XPOS - X coordinate of starting position in miles. Range: 17.0 to 67.0; cols. 1-10.

YPOS - Y coordinate of starting position in miles. Range: 1.0 to 53.0; cols. 11-20.

GOTIME - Simulation start time (local standard time) in hours and decimal fraction of hours. Range: 7.000 to 18.999; cols. 21-30.

PRMT(2) - Length of simulation in minutes and decimal fraction of minutes. Cols 31-40. For backward trajectory, value must be negative. For forward trajectory, value must be positive.

PRMT(3) - Initial value of step size for numerical integration in minutes and decimal fraction of minutes. For backward trajectory, value must be negative. For forward trajectory, value must be positive. Normal range in magnitude is from .001 to .5; cols. 41-50.

PRMT(4) - Upper bound of error in numerical integration. Determines allowable difference between predictor and corrector. Normal range is from .5 to .01; cols. 51-60.

TINT - Output interval. Specifies in minutes how often position print outs are to occur. Normal range is from 5.0 to 30.0 minutes; cols. 61-70.

FORMAT (4F10.3, 3F10.5)

0 1	11 01	22 01	33 01	44 01	55 01	66 01	77 01	8 0
XPOS	YPOS	GOTIME	PRMT(2)	PRMT(3)	PRMT(4)	TINT		

3. Card Type 3

Starting data--4 Items--1 Card (all values must be right justified)

NSTA - Number of meteorological stations; cols. 1-10.

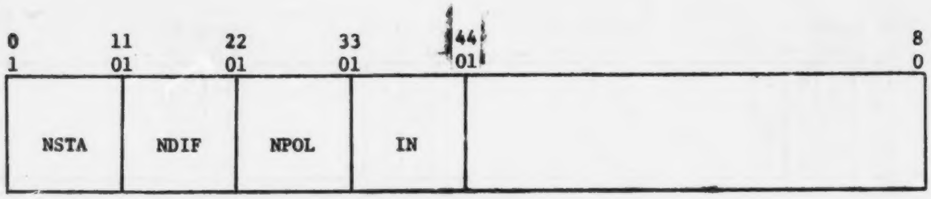
NDIF - Number of accumulating species, usually 0; cols. 11-20.

NPOL - Number of pollutant monitoring stations; cols. 21-30.

IN - Indicates if program is to operate again with data from previous run or a new set of data is necessary.

0 - A complete set of data is necessary for the run.

1 - Rerun with previous data. Must input only card types 1, 2, and 3; cols. 31-40.



4. Card Type 4

Wind velocity data--1 array--maximum of 32 stations.

Use card type 9 from model, or set up cards as follows:

AIR - 3 cards per station, 4 hours per card, 12 hours per station.

IDNUM - Column 1-3, alphanumeric station ID

AIR - Column 4-5, start hour of data, values are 7, 11 or 15,

Column 6, number of readings on card, max = 4

Column 7-12
Column 24-29
Column 41-46
Column 58-63

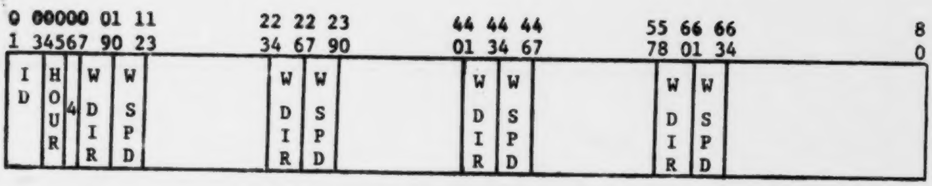
$\Big\}$ hourly data--6 columns

2 items in the 6 columns, 3 columns per item wind direction in degrees, wind speed in miles/hour, last column is in tenths of a mile/hour.

Conversion: wind speed and direction are converted into XDOT and YDOT, the X and Y components of wind velocity at the trajectory point.

FORMAT (A3, 3X, 4(F3.0, F3.1, 11X))

The station order on card types 4 and 5 must be exactly coincidental.



5. Card Type 5--(See Figure 4)

Meteorological Stations--2 arrays--maximum of 8 cards, 4 stations per card.

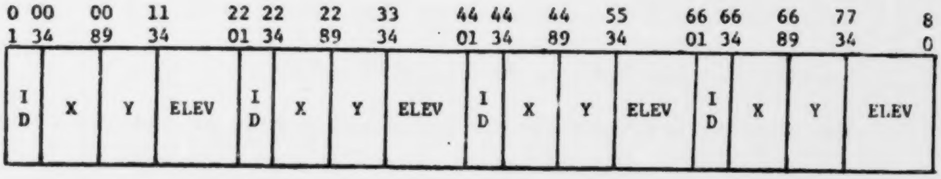
WPOS - Array of quadruplets, 4 stations per card, maximum of 32 stations. Cards are as follows:

IDMET - Column 1-3, alphanumeric station ID code.

WPOS - Column 4-8, X coordinate of station position in miles, last 2 columns in hundreths of miles. Column 9-13, Y coordinate of station position in miles, last 2 columns in hundreths of miles. Column 14-20, ground elevation of station in feet, last 2 columns in hundreths of feet. This 20 column grouping is repeated in columns 21-40, 41-60, 61-80 as required, and on additional cards if necessary.

FORMAT (4(A3, 2F5.2, F7.2))

The station order on card types 4 and 5 must be exactly coincidental.



6. Card Type 6

Pollutant monitoring data--2 arrays--maximum of 5 cards, 4 stations per card.

PPOS - Array of quadruplets, 4 stations per card, maximum of 20 stations.
Cards are as follows:

IDPOL - Column 1-3, alphanumeric station ID code.

PPOS - Column 4-8, X coordinate of station position in miles, last 2 columns in hundreths of miles.

Column 9 - 13, Y coordinate of station position in miles, last 2 columns in hundreths of miles.

Columns 14-20, blank.

This 20 column grouping is repeated in columns 21-40, 41-60, 61-80 as required, and on additional cards if necessary.

FORMAT (4(A3, 2F5.2, F7.2))

The station order card types 6 and 7 must be exactly coincidental.

0	00	00	11	22	22	22	33	44	44	44	55	66	66	66	77	8
1	34	89	34	01	34	89	34	01	34	89	34	01	34	89	34	0
ID	X	Y		ID	X	Y		ID	X	Y		ID	X	Y		

7. Card Type 7

Pollutant monitoring data--2 arrays--maximum of 20 stations.

CONC - 4 cards per station, 3 hours per card, 12 hours per station.
Set up card as follows:

IDPOL - Column 1-3, alphanumeric station ID code.

CONC - Column 4-5, start hour of data, values are 7, 10, 13 or 16,

6, number of readings on card, max = 3.

7-27
28-48 } hourly data--21 columns, all values are in pphm
49-69

5 items in the 21 columns as follows:

4 columns - NO_2, last column is in parts/billion.

4 columns - NO, last column is in parts/billion.

4 columns - O_3, last column is in parts/billion.

4 columns - blank, field not used but has been set aside for input of hydrocarbon data or another pollutant of interest.

5 columns - CO, last column is in parts/billion.

01 03	04 05	06	07 10	11 14	15 18	19 22	23 27	28 31	32 35	36 39	40 43	44 48	49 52	53 56	57 60	61 64	65 69	70 80
ID	HOUR	3	NO_2	NO	O_3		CO	NO_2	NO	O_3		CO	NO_2	NO	O_3		CO	

FORMAT (A3, 3X, 3(3F4.1, 4X, F5.1), 11X)

The station order or card types 6 and 7 must be exactly coincidental.

Section XI

Reverse Trajectory Sample Input Deck

Card Type 1

```
SEPTEMBER 29, 1969   11 30 AM
TERMINATE AT PASADENA
29 METEOROLOGICAL STATIONS, 2 BARRIERS
12 POLLUTANT STATIONS
```

Card Type 2

```
      47.0      42.0      13.5    -300.0      -.25        .1      15.0
```

Card Type 3

```
        29                  12         D
```

Card Type 4

```
NTB074       67611114                           78611117         80621114
NTB114       86621111          90611105         88601099         92581095
NTB154       89561094          84541093         82521096         76521099
NZJ074       63631101                           77621113         84601113
NZJ114       88561107          92571101         92611096         92581091
NZJ154       90581091          88591093         86601093         77591093
CAP074 90 2  70        225 3   75       270 5   79       270 6   80
CAP114270 8  87        270 9   88       270 9   86       270 9   86
CAP154270 8  87        270 8   86       270 5   82       270 6   78
ONT074       6854              7054                              9047
ONT114       9542              9745            10048            10056
ONT154       9952              9760             9248             8638
LAX074350 5  65621113  350 5   69631118 240 9   72641121 240 9   74631119
LAX114240 9  80591116  26014   74621114 26014   73621109 26014   73621103
LAX15426016  72621100  26016   71601099 26016   71601096 230 8   70581096
BUR074    7  7151          1   7356         1   7756         1   8849
BUR114    1  9246          2   9839     180 3   9950     270 4   9950
BUR154315 4 10047      315 4   9642     338 2   9143     270 1   9038
LGB074315 2  67611122  270 3   71611125 270 4   77611125 293 7   84601125
LGB114270 5  87571119  270 8   91561112 27010   89581108 27010   86591105
LGB15427013  86571102  27010   81581102 270 7   77571102 270 3   72551105
ENC074113 2            158 2            293 3            293 3
ENC114293 3            293 5            293 7            293 6
ENC154293 6            270 6            270 5            270 3
ELM074120 3  7459      100 1   8055     140 2   8557     230 4   9055
ELM114220 7  9453      220 9   9752     22010   9846     22011   9643
ELM15424012  9539      25010   9334     200 6   8639     210 8   8850
```

Card Type 4 (Continued)

```
COM074 45 3        315 3        293 4        293 9
COM114293 9        29311        29314        29315
COM15429315        27017        29316        29312
CPK074203 1        135 1        180 1        135 1
CPK114135 1        203 2        158 2        315 4
CPK154338 6        338 6        338 4        315 2
AZU074315 2         90 2        113 2         68 1
AZU114203 5        203 7        225 7        203 9
AZU15420310        20311        203 9        203 5
WHT074338 4        293 2        180 2        248 2
WHT114248 5        270 6        270 6        270 6
WHT154270 6        270 6        270 4        248 3
WLA074270 1        203 1        225 1        225 2
WLA114225 4        225 5        225 4        225 3
WLA154225 4        203 4        203 2        203 1
WNT074 23          158          293          158
WNT114248          248          203          203
WNT154203          248 8        248 7        180 4
VER074270 6        270 2        270 2        270 3
VER114270 3        270 5        225 3        225 5
VER15422511        270 5        270 9        27010
VEN074293 1        248 2        270 5        248 3
VEN114225 6        24810        24810        24811
VEN15424811        248 8        225 6        203 7
RVA074 23 3        338 3         23 3        180 4
RVA114203 5        225 6        248 8        248 9
RVA154248 7        225 7        248 6        225 5
RSD074113 1        248 1        180 1         68 1
RSD114203 1         68 2        135 2         90 2
RSD154270 7        293 8        248 6        270 3
RB 074293 3        248 3        248 4        225 3
RB 114203 5        225 8        225 7        225 8
RB 154225 8        203 7        203 5        203 6
RLA074225 1        360 1        270 1        180 1
RLA114225 1        225 1        270 1        225 1
RLA154225 1        225 1        225 2        225 2
POM074113 2        135 2        248 2        270 2
POM114315 4        315 4        293 4        315 6
POM154293 6        315 6        293 4        293 5
PIC074315 1        360 1        225 1        225 1
PIC114225 1        225 1
PIC154180 1        180 1        225 1        180 1
MAL074225 2        225 3        158 2        203 2
MAL114225 5        225 7        225 5        225 8
MAL15422510        225 8         90 2         90 3
KFI074 23 1        270 1        225 1        293 2
KFI114293 4        315 6        293 8        31510
KFI15431510        315 9        293 7        293 5
HOL074270 1        135 6        270 1        180 1
HOL114225 1        180 1        225 9        225 5
HOL154225 2        225 2        225 6        180 2
```

Card Type 4 (Continued)

```
BKT074 90 5             90 3             90 4            270 4
BKT114270 6            270 7            270 8            27010
BKT15427011            27012            270 9            270 7
PAS074338 2             45 1            225 1            158 2
PAS114180 2            203 3            180 3            225 4
PAS154225 6            225 3            225 2             45 1
CMC074 60 3  7159      150 2   7957     190 5  8558     220 8  8955
CMC114240 7  9355      26010   9450     26012  9152     26012  9148
CMC15426011  8852      27010   8354     250 8  7854     230 5  7455
```

Card Type 5

```
NTB 51   16     27  NZJ 70    8    380  CAP 40   33    300  UNT 76   35    916
LAX 32   27     99  BUR 33   45    530  LGB 45   18     34  ENC 23   44    800
ELM 52   35    300  COM 39   22    100  CPK 19   46    800  AZU 59   41    600
WHT 51   30    250  WLA 30   34    200  WNT 63   30    950  VER 41   31    180
VEN 26   30      5  RVA 48   30    180  RSD 22   46    800  RB  31   21    110
RLA 45   26    100  POM 70   33    850  PIC 33   34    100  MAL 18   34     20
KFI 53   23    100  HOL 35   37    300  BKT 68   36    950  PAS 47   42    870
CMC 44   31    180
```

Card Type 6

```
DLA 40   35         AZU 59   41         BUR 33   45         WLA 30   34
LGB 45   18         RSD 22   46         POM 70   33         LAX 32   27
PAS 47   42         WHT 51   30         CMC 44   31         ELM 52   35
```

Card Type 7

```
DLA073   3  28   2     17    11  36   5     18   19  30   8
DLA103  18  11  12           10   5   9      6            8      3
DLA133   5       7      3         2   5      2    6   3   3      6
DLA163   7   5   2      6     7   6   1      5    5   8   1      4
AZU073  13   4   3     10    16   3   9     11   11   1  16     10
AZU103   8   1  22      8     5   1  24      6           28      7
AZU133          38      9            25      6    5   1  14      6
AZU163   7   1   7      4     7   1   2      5   11   1   1      7
BUR073  17  34   2     18    25  27   4     17   29  14   7      9
BUR103  28   7  11     11    19   3  14     10           21     11
BUR133          14      7            11      7   11   1   5      5
BUR163  10   2   3      5    11   3   2      6   17  12   2     12
WLA073  12  35   1     17    21  38   3     17   19   6   5      8
WLA103  14   3  10                   12      5           10      4
WLA133   8   1  10      4     8   1   6      4    8   2   4      4
WLA163   9   3   2      5    10   5   1      4    9   1   3      4
LGB073   9  26   1     13    17  18   1     11   28  10   2      9
LGB103  20   9   2      6    22   8   6      6            2      6
LGB133  19  16   1      5     6  18   1      5   13  21   1      5
LGB163  11  21   1      5     9  21   1      5    8  20   1      4
```

Card Type 7 (Continued)

RSD073	13	11	4	16	21	7	9	11	17	1	12	8
RSD103	10	1	14	6	4	1	10	4			17	5
RSD133			9	3			6	3	2	1	7	5
RSD163	3	1	4	5	3	1	3	5	4	1	2	6
POM073	18	6	3	9	21	4	9	9	15	1	16	
POM103	10	1	19	6	10	1	14	5			15	4
POM133			21	5	5	1	21	6	8	1	16	6
POM163	13	2	6	6	13	2	6	5	14	3	3	6
LAX073	10	20	2	9	13	9	2	5	10	6	3	5
LAX103	11	4	4	6			10				7	3
LAX133			8	3	5	1	5	4	6	2	4	6
LAX163	7	3	4	6	8	3	4	5	9	5	1	3
PAS073	10	16	2		9	2	9		6	1	17	
PAS103	6	1	26		12	1	41				32	
PAS133	5	1	20		8	2	12		6	1	9	
PAS163	5	1	6		6	2	3		9	5	2	
WHT073	19	34	2	14	30	9	6	11	37	3	11	11
WHT103	41	2	21	13	21	1	34				30	2
WHT133	10	1	19	1	9	1	12	1	10	1	7	1
WHT163	12	2	4	1	9	1	5	1	11	1	3	1
CMC073	16	32		17	26	22		15	32	15		15
CMC103	25	7		9	14	6	9	6	10	3	5	4
CMC133	9	9	2	3	7	6	2	3	7	9	1	4
CMC163	4	8		4	3		2	3	5			3
ELM073							2	8			6	6
ELM103			13	6		22		9			23	5
ELM133			14	3		9		2			5	2
ELM163			2					4			3	5

Section XII

Reverse Trajectory Program Listing

```
C                                                                       BD0001
      DIMENSION Y(40),DERY(40),IONUM(32),IR(50,5),DAIR(12,32,2),PRMT(6),BD0002
     1          A(80),IDMET(32),IDPOL(32)                               BE0003
      DOUBLE PRECISION AUX,C,D,DELT,DERY,H,X,Y,YY,Z,ZZ                  BD0004
      COMMON /RECOM/ TIME,ANS(8),DERIV(8), NSTA,NPOL,AIR(12,32,2),      BD0005
     1     WPOS(32,3),GOTIME                                            BD0006
C                                                                       BD0007
      COMMON /BARRR/ IDB                                                BD0008
      COMMON /OUTCOM/ TOUT,TINT                                         BD0009
      COMMON  /MILES/ COORD(2),DXY(2)                                   BD0010
      REAL*4 NO2,NO                                                     BD0011
      DIMENSION CONC(12,20,5),PPOS(32,3),ID(20)                         BE0012
C                                                                       BD0013
C     GOTIME--SIMULATION START TIME                                     BD0014
C                                                                       BD0015
      EXTERNAL RWIND,PUTOUT                                             BD0016
C                                                                       BD0017
C     INITIALIZATION                                                    BD0018
C                                                                       BD0019
C                                                                       BD0020
C     INPUT HEADING INFORMATION                                         BD0021
C                                                                       BD0022
    1 READ (5,1000,END=900) A                                           BD0024
      DO 10  I=1,40                                                     BD0025
      Y(I) = 0.0D0                                                      BD0026
   10 DERY(I) = 0.0D0                                                   BD0027
      TOUT = 0.0                                                        BD0028
      N = 0                                                             BD0029
      IDB = 0                                                           BD0030
C                                                                       BD0031
C            SIZE, UPPER BOUND ERROR LIMIT, AND OUTPUT INTERVAL         BD0033
C                                                                       BD0034
      READ (5,1001) XPOS,YPOS,GOTIME,PRMT(2),PRMT(3),PRMT(4),TINT       BD0035
C     INPUT START POSITION,START TIME, LENGTH OF SIMULATION, INTIAL STEPBD0032
   75 PRMT(1) = 0.                                                      BD0036
C     READ NO. METEOR. STATIONS, NO. OF EQUAT., NO. OF POLLUTANT STA.   BE003620
C                                                                       BE003640
C                                                                       BD0037
      READ (5,1002)  NSTA,NDIF,NPOL,IN                                  BE0038
C                                                                       BD0039
C                                                                       BD0040
C                                                                       BD0041
C     SET UP POSITION FOR INTEGRATION                                   BD0042
C                                                                       BD0043
      Y(NDIF+1) = XPOS*1609.3                                           BD0044
      Y(NDIF+2) = YPOS*1609.3                                           BD0045
C                                                                       BD0046
C     CHECK FOR SECOND RUN                                              BD0047
C                                                                       BD0048
      IF (IN .EQ. 1)   GO TO 300                                        BD0049
C                                                                       BD0051
C     INPUT METEOROLOGICAL DATA.                                        BD0052
C                                                                       BD0053
```

```
      DO 100  J=1,NSTA                                                    BD0054
      READ (5,1005)  IDNUM(J),((AIR(I,J,K),K=1,2),I=1,4)                  BE0055
      READ (5,1005)  IDNUM(J),((AIR(I,J,K),K=1,2),I=5,8)                  BE0056
  100 READ (5,1005)  IDNUM(J),((AIR(I,J,K),K=1,2),I=9,12)                 BE0057
C                                                                         BD0058
C     INPUT METEOROLOGICAL STATION DATA                                   BD0059
C                                                                         BD0060
      WRITE (6,1013)                                                      BD0061
      READ (5,1014) (IDMET(I),(WPOS(I,J),J=1,3),I=1,NSTA)                 BE0062
C                                                                         BD0063
C     CONVERT DATA TO METRIC UNITS                                        BD0064
C                                                                         BD0065
      DO 120  I=1,NSTA                                                    BD0066
  120 WPOS(I,3) = WPOS(I,3)*.3048                                         BD0067
C                                                                         BD0068
C     READ POLLUTANT STATION POSITIONS                                    BD0069
C                                                                         BD0070
      READ (5,1014) (IDPOL(I),(PPOS(I,J),J=1,3),I=1,NPOL)                 BE0071
C                                                                         BD0072
C     READ POLLUTANT DATA                                                 BD0073
C                                                                         BD0074
      DO 140  J=1,NPOL                                                    BD0075
      READ (5,1005)  ID(J),((CONC(I,J,K),K=1,4),I=1,3)                    BE0076
      READ (5,1006)  ID(J),((CONC(I,J,K),K=1,4),I=4,6)                    BE0077
      READ (5,1006)  ID(J),((CONC(I,J,K),K=1,4),I=7,9)                    BE007750
  140 READ (5,1006)  ID(J),((CONC(I,J,K),K=1,4),I=10,12)                  BE0078
C                                                                         BD0079
C     OUTPUT METEOROLOGICAL DATA                                          BD0080
C                                                                         BD0081
      WRITE (6,1015) (IDMET(I),(WPOS(I,J),J=1,3),I=1,NSTA)                BE0082
      KOUT = 0                                                            BD0083
      WRITE (6,1007)                                                      BD0084
      DO 180  I=1,12                                                      BD0085
      IH = (I+6)*100                                                      BD0086
      DO 180  J=1,NSTA                                                    BD0087
      IF (KOUT .LE. 50)   GO TO 170                                       BD0088
      KOUT = 0                                                            BD0089
      WRITE (6,1007)                                                      BD0090
      GO TO 180                                                           BD0091
  170 KOUT = KOUT+1                                                       BD0092
  180 WRITE (6,1008)  IDNUM(J),IH,(AIR(I,J,K),K=1,2)                      BD0093
C                                                                         BD0094
C     WRITE POLLUTANT DATA                                                BD0095
C                                                                         BD0096
      WRITE (6,1009)                                                      BD0097
      WRITE (6,1016) (ID(I),PPOS(I,1),PPOS(I,2),I=1,NPOL)                 CB0098
      KOUT = 0                                                            BD0100
      WRITE (6,1010)                                                      BD0101
      DO 150  I=1,12                                                      BD0102
      IH = (I+6)*100                                                      BD0103
      DO 150  J=1,NPOL                                                    BD0104
      IF (KOUT .LE. 50)  GO TO 145                                        BD0105
      KOUT = 0                                                            BD0106
      WRITE (6,1010)                                                    BD0107
      GO TO 150                                                         BD0108
  145 KOUT = KOUT+1                                                     BD0109
  150 WRITE (6,1011)  ID(J),IH,(CONC(I,J,K),K=1,4)                      BE0110
C                                                                       BD0111
C     SAVE  WIND DATA                                                   BD0112
C                                                                       BD0113
      DO 200  J=1,12                                                    BD0114
      DO 200  I=1,NSTA                                                  BD0115
      DAIR(J,I,1) = AIR(J,I,2)                                          BD0116
  200 DAIR(J,I,2) = AIR(J,I,1)                                          BD0117
C                                                                       BD0118
C     CONVERT WIND DATA TO RADIANS                                      BD0119
C                                                                       BD0120
      DO 230  J=1,12                                                    BD0121
      DO 230  I=1,NSTA                                                  BD0122
      AIR(J,I,1) = -DAIR(J,I,1)*SIN(DAIR(J,I,2)*3.14159/180.)           BD0123
  230 AIR(J,I,2) = -DAIR(J,I,1)*COS(DAIR(J,I,2)*3.14159/180.)           BD0124
C                                                                       BD0125
  300 WRITE (6,1025) PRMT(2),         PRMT(3),PRMT(4),GOTIME,A          BD0126
      CALL SMGDRV (PRMT,Y,DERY,2,2,IHLF,RWIND,PUTOUT)                   BD0127
      CALL POLLUT (TIME,COORD(1),COORD(2),CONC,NPOL,NO2,NO,O3,CO,PPOS)  BE0128
      WRITE (6,1012)  NO2,NO,O3,CO                                      BE0129
      WRITE (6,1026)  IHLF                                              BD0132
      GO TO 1                                                           BD0133
  900 STOP                                                              BD0134
 1000 FORMAT(20A4)                                                      BD0135
 1001 FORMAT(4F10.3,3F10.5)                                             BD0136
 1002 FORMAT(4I10)                                                      BE0137
 1005 FORMAT(A3,3X,4(F3.0,F3.1,11X))                                    BE0138
 1006 FORMAT(A3,3X,3(3F4.1,4X,F5.1),11X)                                BE0139
 1007 FORMAT(1H1,'STATION',5X,'DATA',6X,'WIND',6X,'WIND',/              BD0140
     1        ' ','NUMBER',6X,'HOUR',5X,'DIR.',5X,'SPEED',/             BD0141
     2        ' ',22X,'(DEG)',5X,'(MPH)',//)                            BD0142
 1008 FORMAT(' ',A7,6X,I4,2F10.3)                                       BE0143
 1009 FORMAT(1H1,20X,'POLLUTANT STATIONS',/1H0,'STATION',11X,'X-COORD', CB0144
    1 11X,'Y-COORD',/' ',18X,'(MILES)',11X,'(MILES)',/)                 CB0145
 1010 FORMAT(1H1,'STATION',6X,'HOUR',7X,'NO2',8X,'NO',8X,'O3',3X,'CO',/ BD0146
    1  ' ',21X,'(PPHM)',4X,'(PPHM)',4X,'(PPHM)',4X,'(PPHM)',//)         BD0147
 1011 FORMAT(' ',A7,6X,I4,4F10.1)                                       BE0148
 1012 FORMAT(////'0NO2=',E15.8,10X,'NO=',E15.8,10X,'O3=',E15.8,10X,     BE014820
    1    'CO=',E15.8)                                                   BE014825
 1013 FORMAT(1H1,30X,'METEOROLOGICAL STATIONS',/1H0,21X,'X-COORD',11X,  BE0149
    1'Y-COORD',10X,'ELEVATION',/' ',3X,'STATION',11X,'(MILES)',11X,     BE0150
    2'(MILES)',11X,'(METERS)'/)                                         BE0151
 1014 FORMAT(4(A3,2F5.2,F7.2))                                          BE0152
 1015 FORMAT(' ',A10,2F18.3,F19.3)                                      BE0153
 1016 FORMAT(' ',A7,2F18.3)                                             CB015320
 1025 FORMAT ('1',E10.4,' MIN SIMULATION                    STEP SIZE=', BD0154
    1 E10.4,'   ERROR=',E10.4,/' STARTING TIME=',E10.4,/,4(' ',20A4,/))CA0155
 1026 FORMAT('0IHLF = ',I4)                                             CA0156
      END                                                               BD0157
      SUBROUTINE SMGDRV (PRMT,Y,DERY,NDIM,NSPEC,IHLF,SMGFCT,SMGOUT)     BD0158
C                                                                       BD0159
C                                                                       BD0160
      DIMENSION PRMT(1),Y(1),DERY(1),AUX(16,50)                         BD0161
      DOUBLE PRECISION AUX,C,D,DELT,DERY,H,X,Y,YY,Z,ZZ                  BD0162
      N=1                                                               BD0163
      IHLF=0                                                            BD0164
      X=PRMT(1)                                                         BD0165
      DELT = 0.D0                                                       BD0166
      H=PRMT(3)                                                         BD0167
      ISTEP = 0                                                         BD0168
      DO 1 I=1,NDIM                                                     BD0169
      AUX(16,I)=0.D0                                                    BD0170
      AUX(15,I)=DERY(I)                                                 BD0171
    1 AUX(1,I)=Y(I)                                                     BD0172
      IF(H*(PRMT(2)-X))3,2,4                                            BD0173
C                                                                       BD0174
C     ERROR RETURNS                                                     BD0175
    2 IHLF=12                                                           BD0176
      GOTO 4                                                            BD0177
    3 IHLF=13                                                           BD0178
C                                                                       BD0179
C     COMPUTATION OF DERY FOR STARTING VALUES                           BD0180
    4 CALL SMGFCT (X,Y,DERY,-1)                                         BD0181
C                                                                       BD0182
C     RECORDING OF STARTING VALUES                                      BD0183
      CALL SMGOUT (X,Y,DERY,DELT,H,IHLF)                                BD0184
    5 IF(IHLF)7,7,6                                                     BD0185
    6 RETURN                                                            BD0186
    7 DO 8 I=1,NDIM                                                     BD0187
    8 AUX(8,I)=DERY(I)                                                  BD0188
C                                                                       BD0189
C     COMPUTATION OF AUX(2,I)                                           BD0190
      ISW=1                                                             BD0191
      GOTO 100                                                          BD0192
C                                                                       BD0193
    9 X=X+H                                                             BD0194
      DO 10 I=1,NDIM                                                    BD0195
   10 AUX(2,I)=Y(I)                                                     BD0196
C                                                                       BD0197
C     INCREMENT H IS TESTED BY MEANS OF BISECTION                       BD0198
   11 IHLF=IHLF+1                                                       BD0199
      X=X-H                                                             BD0200
      DO 12 I=1,NDIM                                                    BD0201
   12 AUX(4,I)=AUX(2,I)                                                 BD0202
      H=.5D0*H                                                          BD0203
      N=1                                                               BD0204
      ISW=2                                                             BD0205
      GOTO 100                                                          BD0206
C                                                                       BD0207
   13 X=X+H                                                             BD0208
      CALL SMGFCT (X,Y,DERY,1)                                          BD0209
      N=2                                                               BD0210
      DO 14 I=1,NDIM
      AUX(2,I)=Y(I)
   14 AUX(9,I)=DERY(I)
      ISW=3
      GOTO 100
C
C     COMPUTATION OF TEST VALUE DELT
C     SET DELT TO MAX PREDICTOR-CORRECTOR DIFFERENCE
   15 DELT = DABS(Y(1)-AUX(4,1))
      DO 16  I=2,NSPEC
      IF (DABS(Y(I)-AUX(4,I)) .GT. DELT)    DELT = DABS(Y(I)-AUX(4,I))
   16 CONTINUE
      IF(DELT-PRMT(4))19,19,17
   17 IF(IHLF-10)11,18,18
C
C     NO SATISFACTORY ACCURACY AFTER 10 BISECTIONS. ERROR MESSAGE.
   18 IHLF=11
      X=X+H
      GOTO 4
C
C     THERE IS SATISFACTORY ACCURACY AFTER LESS THAN 11 BISECTIONS.
   19 X=X+H
      DO 20 I=1,NDIM
      AUX(3,I)=Y(I)
   20 AUX(10,I)=DERY(I)
      N=3
      ISW=4
      GOTO 100
C
   21 N=1
      X=X+H
      CALL SMGFCT (X,Y,DERY,1)
      X=PRMT(1)
      DO 22 I=1,NDIM
      AUX(11,I)=DERY(I)
   220Y(I)=AUX(1,I)+H*(.37500*AUX(8,I)+.79166666666666667D0*AUX(9,I)
     1-.20833333333333333D0*AUX(10,I)+.04166666666666667D0*DERY(I))
   23 X=X+H
      N=N+1
      CALL SMGFCT (X,Y,DERY,-1)
      CALL SMGOUT (X,Y,DERY,DELT,H,IHLF)
   24 IF (N-4) 25,201,201
   25 DO 26 I=1,NDIM
      AUX(N,I)=Y(I)
   26 AUX(N+7,I)=DERY(I)
      IF (N-3) 27,29,201
C
   27 DO 28 I=1,NDIM
      DELT=AUX(9,I)+AUX(9,I)
      DELT=DELT+DELT
   28 Y(I)=AUX(1,I)+.33333333333333333D0*H*(AUX(8,I)+DELT+AUX(10,I))
      GOTO 23
C
```

```
   29 DO 30 I=1,NDIM
      DELT=AUX(9,I)+AUX(10,I)
      DELT=DELT+DELT+DELT
   30 Y(I)=AUX(1,I)+.375D0*H*(AUX(8,I)+DELT+AUX(11,I))
      GOTO 23
C
C
C     *****************************************************************
C     THE FOLLOWING PART OF SUBROUTINE DHPCG COMPUTES BY MEANS OF
C     RUNGE-KUTTA METHOD STARTING VALUES FOR THE NOT SELF-STARTING
C     PREDICTOR-CORRECTOR METHOD.
  100 DO 101 I=1,NDIM
      Z=H*AUX(N+7,I)
      AUX(5,I)=Z
  101 Y(I)=AUX(N,I)+.4D0*Z
C     Z IS AN AUXILIARY STORAGE LOCATION
C
      Z=X+.4D0*H
      CALL SMGFCT (Z,Y,DERY,1)
      DO 102 I=1,NDIM
      Z=H*DERY(I)
      AUX(6,I)=Z
  102 Y(I)=AUX(N,I)+.29697760924775360D0*AUX(5,I)+.15875964497103583D0*Z
C
      Z=X+.45573725421878943D0*H
      CALL SMGFCT (Z,Y,DERY,1)
      DO 103 I=1,NDIM
      Z=H*DERY(I)
      AUX(7,I)=Z
  103 Y(I)=AUX(N,I)+.21810038822592047D0*AUX(5,I)-3.0509651486929308D0*
     1AUX(6,I)+3.8328647604670103D0*Z
C
      Z=X+H
      CALL SMGFCT (Z,Y,DERY,1)
      DO 104 I=1,NDIM
  1040Y(I)=AUX(N,I)+.17476028226269037D0*AUX(5,I)-.55148066287873294D0*
     1AUX(6,I)+1.2055355993965235D0*AUX(7,I)+.17118478121951903D0*
     2H*DERY(I)
      GOTO(9,13,15,21),ISW
C     *****************************************************************
C
C
C     POSSIBLE BREAK-POINT FOR LINKAGE
C
C
C     STARTING VALUES ARE COMPUTED.
C     NOW START HAMMINGS MODIFIED PREDICTOR-CORRECTOR METHOD
  201 IF(N-8)204,202,204
C
C     N>8 CAUSES THE ROWS OF AUX TO CHANGE THEIR STORAGE LOCATIONS
  202 DO 203 N=2,7
      DO 203 I=1,NDIM
      AUX(N-1,I)=AUX(N,I)
  203 AUX(N+6,I)=AUX(N+7,I)
      N=7
C
C     N LESS THAN 8 CAUSES N+1 TO GET N
  204 N=N+1
C
C     COMPUTATION OF NEXT VECTOR Y
      DO 205 I=1,NDIM
      AUX(N-1,I)=Y(I)
  205 AUX(N+6,I)=DERY(I)
      X=X+H
  206 DO 207  I=1,NDIM
     0DELT=AUX(N-4,I)+1.3333333333333333D0*H*(AUX(N+6,I)+AUX(N+6,I)-
     1AUX(N+5,I)+AUX(N+4,I)+AUX(N+4,I))
      Y(I)=DELT-.92561983471074380D0*AUX(16,I)
  207 AUX(16,I)=DELT
C     PREDICTOR IS NOW GENERATED IN ROW 16 OF AUX, MODIFIED PREDICTOR
C     IS GENERATED IN Y. DELT MEANS AN AUXILIARY STORAGE.
C
      CALL SMGFCT (X,Y,DERY,-1)
C     DERIVATIVE OF MODIFIED PREDICTOR IS GENERATED IN DERY
C
      DO 208 I=1,NDIM
     0DELT=.125D0*(9.D0*AUX(N-1,I)-AUX(N-3,I)+3.D0*H*(DERY(I)+AUX(N+6,I)
     1+AUX(N+6,I)-AUX(N+5,I)))
      AUX(16,I)=AUX(16,I)-DELT
  208 Y(I)=DELT+.07438016528925620D0*AUX(16,I)
C
C     TEST WHETHER H MUST BE HALVED OR DOUBLED
C   SET DELT TO MAX PREDICTOR-CORRECTOR DIFFERENCE
      DELT = DABS(AUX(16,1))
      DO 209  I=2,NSPEC
      IF (DABS(AUX(16,I)) .GT. DELT)      DELT = DABS(AUX(16,I))
  209 CONTINUE
      IF (DELT .GE. PRMT(4))   GO TO 222
      IHLF = 0
C
C     H MUST NOT BE HALVED. THAT MEANS Y(I) ARE GOOD.
  210 CALL SMGOUT (X,Y,DERY,DELT,H,IHLF)
  211 IF(IHLF-11)213,212,212
  212 RETURN
C
C     CHECK IF END TIME REACHED.
  213 IF(H*(X-PRMT(2)-0.1D 1)) 214,250,250
  214 IF(DABS(X-PRMT(2)-0.1D 1)-.1D0*DABS(H)) 250,215,215
  215 IF (DELT .LT. .01*PRMT(4))   GO TO 217
  216 ISTEP = 0
      GO TO 201
C
C     H COULD BE DOUBLED IF ALL NECESSARY PRECEEDING VALUES ARE
C     AVAILABLE.  CHECK FOR 8 CONSECUTIVE DELTS WITHIN LIMIT.
  217 IF (ISTEP-7)    218,219,219
  218 ISTEP = ISTEP+1
```

```
      GO TO 201                                                         BD0370
  219 IF (DABS(H)-17.0)  220,216,216                                    BD0371
  220 H=H+H                                                             BD0372
      ISTEP=0                                                           BD0373
      DO 221 I=1,NDIM                                                   BD0374
      AUX(N-1,I)=AUX(N-2,I)                                             BD0375
      AUX(N-2,I)=AUX(N-4,I)                                             BD0376
      AUX(N-3,I)=AUX(N-6,I)                                             BD0377
      AUX(N+6,I)=AUX(N+5,I)                                             BD0378
      AUX(N+5,I)=AUX(N+3,I)                                             BD0379
      AUX(N+4,I)=AUX(N+1,I)                                             BD0380
      DELT=AUX(N+6,I)+AUX(N+5,I)                                        BD0381
      DELT=DELT+DELT+DELT                                               BD0382
  2210AUX(16,I)=8.962962962962963D0*(Y(I)-AUX(N-3,I))                  BD0383
     1-3.3611111111111111D0*H*(DERY(I)+DELT+AUX(N+4,I))                 BD0384
      GOTO 201                                                          BD0385
C                                                                       BD0386
C                                                                       BD0387
C     H MUST BE HALVED                                                  BD0388
  222 IHLF=IHLF+1                                                       BD0389
      IF(IHLF-10)223,223,210                                            BD0390
  223 H=.5D0*H                                                          BD0391
      ISTEP=0                                                           BD0392
      DO 224 I=1,NDIM                                                   BD0393
     0Y(I)=.390625D-2*(8.D1*AUX(N-1,I)+135.D0*AUX(N-2,I)+4.D1*AUX(N-3,I)BD0394
     1+AUX(N-4,I))-.1171875D0*(AUX(N+6,I)-6.D0*AUX(N+5,I)-AUX(N+4,I))*H BD0395
     0AUX(N-4,I)=.390625D-2*(12.D0*AUX(N-1,I)+135.D0*AUX(N-2,I)+        BD0396
     1108.D0*AUX(N-3,I)+AUX(N-4,I))-.0234375D0*(AUX(N+6,I)+             BD0397
     218.D0*AUX(N+5,I)-9.D0*AUX(N+4,I))*H                               BD0398
      AUX(N-3,I)=AUX(N-2,I)                                             BD0399
  224 AUX(N+4,I)=AUX(N+5,I)                                             BD0400
      X=X-H                                                             BD0401
      DELT=X-(H+H)                                                      BD0402
      CALL SMGFCT (DELT,Y,DERY,1)                                       BD0403
      DO 225 I=1,NDIM                                                   BD0404
      AUX(N-2,I)=Y(I)                                                   BD0405
      AUX(N+5,I)=DERY(I)                                                BD0406
  225 Y(I)=AUX(N-4,I)                                                   BD0407
      DELT=DELT-(H+H)                                                   BD0408
      CALL SMGFCT (DELT,Y,DERY,1)                                       BD0409
      DO 226 I=1,NDIM                                                   BD0410
      DELT=AUX(N+5,I)+AUX(N+4,I)                                        BD0411
      DELT=DELT+DELT+DELT                                               BD0412
     0AUX(16,I)=8.962962962962963D0*(AUX(N-1,I)-Y(I))                   BD0413
     1-3.3611111111111111D0*H*(AUX(N+6,I)+DELT+DERY(I))                 BD0414
  226 AUX(N+3,I)=DERY(I)                                                BD0415
      GOTO 206                                                          BD0416
  250 IHLF = 30                                                         BD0417
      GO TO 210                                                         BD0419
      END                                                               BD0420
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G LEVEL  20                    PUTOUT               DATE = 72342          21/45/45

          SUBROUTINE PUTOUT (TIME,Y,DERY,DELTA,SIZE,IHLF)                       BE0421
          DIMENSION Y(1),DERY(1)                                                BD0422
          DOUBLE PRECISION DELTA,DERY,SIZE,TIME,Y                               BD0423
          COMMON /OUTCOM/ TOUT,TINT                                             BD0424
          COMMON  /MILES/ COORD(2),DXY(2)                                       BD0425
          IF (IHLF .NE. 30)     GO TO 50                                        BE0426
          GO TO 100                                                             BD0428
       50 IF (DABS(TIME) .GE. TOUT)   GO TO 100                                 BD0429
          GO TO 2000                                                            BD0430
      100 WRITE (6,1000) TIME,COORD(1),COORD(2),SIZE                            CB0431
          TOUT = TOUT+TINT                                                      BD0432
     1000 FORMAT('0TIME=',D15.8,15X,'POSITION=',2F15.4,15X,'SIZE=',D15.8)       CB0433
     2000 RETURN                                                                BD0436
          END                                                                   BD0437
      SUBROUTINE RWIND(XTIME,Y,DERY,NOT)                                BD0438
C                                                                       BD0439
      DIMENSION Y(1),DERY(1),DIST(32),JBAR(32),VAL1(8),VAL2(8),         CA0440
     1   DISINV(32)                                                     CA044010
      DOUBLE PRECISION  DERY,XTIME,Y                                    BD0441
      COMMON  /MILES/ COORD(2),DXY(2)                                   BD0442
      COMMON /RECOM/ TIME,ANS(8),DERIV(8), NSTA,NPOL,AIR(12,32,2),      BD0443
     1    WPOS(32,3),GOTIME                                             BD0444
C                                                                       BD0445
C     SET TIME AND POSITION                                             BD0446
C                                                                       BD0447
      TIME = GOTIME+XTIME/60.                                           BD0448
      ITIME = TIME-6                                                    BD0449
      COORD(1) = Y(1)/1609.3                                            BD0450
      COORD(2) = Y(2)/1609.3                                            BD0451
      DO 10  I=1,32                                                     BD0452
      DISINV(I) = 0.                                                    BD0453
   10 DIST(I) = 0.                                                      BD0454
      DO 15  I=1,8                                                      BD0455
      VAL1(I) = 0.                                                      CA045520
      VAL2(I) = 0.                                                      CA045540
   15 ANS(I) = 0.                                                       BD0456
C                                                                       BD0457
C     DETERMINE USABLE STATIONS AND SET STATION DISTANCES               BD0458
C                                                                       BD0459
      CALL BARIER (COORD(1),COORD(2),WPOS,JBAR,NSTA)                    BD0460
      DO 30  I=1,NSTA                                                   BD0461
      IF (JBAR(I) .NE. 1)   GO TO 30                                    BD0462
      DIST(I) = (COORD(1)-WPOS(I,1))**2 + (COORD(2)-WPOS(I,2))**2       BD0463
      IF (DIST(I) .NE. 0)   GO TO 30                                    BD0464
      IONE = I                                                          BD0465
      GO TO 100                                                         CA0466
   30 CONTINUE                                                          BD0467
C                                                                       BD0468
C     SET XDOT AND YDOT INTERPOLATED BETWEEN TWO SUCESSIVE HOURS        CA0469
C                                                                       BD0470
      DO 50  J=1,2                                                      BD0471
      DO 40  I=1,NSTA                                                   BD0472
      IF (JBAR(I) .NE. 1)   GO TO 40                                    BD0473
      IF (AIR(ITIME+1,I,J) .EQ. 0.)     GO TO 40                        CA0474
      DISINV(J) = DISINV(J)+1./DIST(I)                                  BD0475
      VAL2(J) = VAL2(J)+AIR(ITIME+1,I,J)/DIST(I)                        CA0476
   40 CONTINUE                                                          BD0477
      IF (DISINV(J) .NE. 0)   GO TO 45                                  BD0478
      VAL2(J) = 0.                                                      CA0479
      GO TO 50                                                          BD0480
   45 VAL2(J) = VAL2(J)/DISINV(J)                                       CA0481
   50 CONTINUE                                                          BD0482
      DO 60  I=1,2                                                      CA0483
   60 DISINV(I) = 0.                                                    CA048320
      DO 80 J=1,2                                                       CA048340
      DO 70 I=1,NSTA                                                    CA048360
      IF (JBAR(I) .NE. 1)  GO TO 70                                     CA048380
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         IF (AIR(ITIME,I,J) .EQ. 0.)  GO TO 70                                  CA0484
         DISINV(J) = DISINV(J) + 1./DIST(I)                                     CA048420
         VAL1(J) = VAL1(J)+AIR(ITIME,I,J)/DIST(I)                               CA048440
      70 CONTINUE                                                               CA048460
         IF (DISINV(J) .NE. 0.)   GO TO 75                                      CA048480
         VAL1(J) = 0.                                                           CA0485
         GO TO 80                                                               CA048520
      75 VAL1(J) = VAL1(J)/DISINV(J)                                            CA048540
      80 CONTINUE                                                               CA048560
         TIMEHR = TIME-(ITIME+6)                                                CA048580
         DO 90  J=1,2                                                           CA0486
      90 ANS(J) = VAL1(J)+(VAL2(J)-VAL1(J))*TIMEHR                              CA048620
         GO TO 120                                                              CA048640
C                                                                               CA048660
C        ONLY ONE STATION                                                       CA048670
C                                                                               CA048680
     100 DO 110  J=1,2                                                          CA0487
     110 ANS(J) = AIR(ITIME,IONE,J)                                             CA0488
     120 DO 130  I=1,2                                                          CA0489
         DXY(I) = ANS(I)/60.                                                    BD0490
     130 DERY(I) = DXY(I)*1609.3                                                CA0491
         RETURN                                                                 BD0492
         END                                                                    BD0493
      SUBROUTINE POLLUT (TIME,X,Y,CONC,NPOL,A1,A2,A3,A4,PPOS)
C
C     CALCULATE POLLUTANT STARTING VALUES
C
      DIMENSION CONC(12,20,5),VAL(5),DISINV(32),DIST(32),JBAR(32),
     1    PPOS(32,3)
      ITIME = TIME-6
      DO 10  I=1,NPOL
      DISINV(I) = 0.
   10 DIST(I) = 0.
      DO 15  I=1,4
   15 VAL(I) = 0.
C
C     DETERMINE USABLE STATIONS AND SET STATION DISTANCES
C
      CALL BARIER (X,Y,PPOS,JBAR,NPOL)
      DO 30  I=1,NPOL
      IF (JBAR(I) .NE. 1)   GO TO 30
      DIST(I) = (X-PPOS(I,1))**2 + (Y-PPOS(I,2))**2
      IF (DIST(I) .NE. 0)   GO TO 30
      IONE = I
      GO TO 60
   30 CONTINUE
C
C     SET POLLUTANT VALUES
C
      DO 50  J=1,4
      DO 40  I=1,NPOL
      IF (JBAR(I) .NE. 1)   GO TO 40
      IF (CONC(ITIME,I,J) .EQ. 0)   GO TO 40
      DISINV(J) = DISINV(J)+1./DIST(I)
      VAL(J) = VAL(J)+CONC(ITIME,I,J)/DIST(I)
   40 CONTINUE
      IF (DISINV(J) .NE. 0)   GO TO 45
      VAL(J) = 0.
      GO TO 50
   45 VAL(J) = VAL(J)/DISINV(J)
   50 CONTINUE
      GO TO 80
   60 DO 70  J=1,4
   70 VAL(J) = CONC(ITIME,IONE,J)
   80 A1 = VAL(1)
      A2 = VAL(2)
      A3 = VAL(3)
      A4 = VAL(4)
      RETURN
      END
      SUBROUTINE BARIER (X,Y,WPOS,JBAR,NPOS)
C
C     DETERMINES IF INTERSECTION OF LINE SEGMENT CONNECTING TRAJECTORY
C     POINT AND STATION AND THE BARRIER LINE SEGMENT LIES ON THE BARRIER
C     ITSELF.  EVALUATE FUNCTIONS ALPHA AND BETA.  IF THEY ARE BOTH LESS
C     THAN 1 AND GREATER THAN 0, STATION IS ELIMINATED.
C
      DIMENSION WPOS(32,3),JBAR(32),BAR(10,10),BSLOPE(10,10),
     1          TSLOPE(32,2)
C
C     NBAR IS NUMBER OF BARRIERS
C     ARRAY BAR---ODD COLUMNS CONTAIN X COORDINATES
C                 EVEN COLUMNS CONTAIN Y COORDINATES
C                 ROW 1 IN ODD COLUMNS CONTAIN NO. OF POINTS IN BARRIER
C     ARRAY BSLOPE--ODD COLUMNS CONTAIN M VALUES OF BARRIER LINE SEGMTS
C                 EVEN COLUMNS CONTAIN Y VALUES OF BARRIER LINE SEGMENTS
C     ARRAY TSLOPE--ODD COLUMN CONTAINS M VALUES OF TRAJECTORY POINT
C                       WEATHER STATION LINE SEGMENT
C                 EVEN COLUMN CONTAINS B VALUES OF TRAJECTORY POINT
C                       WEATHER STATION LINE SEGMENT
C
      COMMON /BARRR/ IDB
      DATA NBAR/ 2/, BAR/2.,16.,38.,8*0.,2*40.,7*0.,4.,53.,60.,66.,71.,
     &          6*0.,31.,28.,32.,23.,65*0./
C
C     DETERMINE SLOPE AND INTERCEPT FROM INTERPOLATION POINT TO EACH
C           STATION.
C
      DO 50  I=1,NPOS
      TSLOPE(I,1) = 0.
50    TSLOPE(I,2) = 0.
      DO 100  I=1,NPOS
      IF((WPOS(I,1)-X) .EQ. 0.)  GO TO 100
      TSLOPE(I,1) = (WPOS(I,2)-Y)/(WPOS(I,1)-X)
      TSLOPE(I,2) = Y-TSLOPE(I,1)*X
100   CONTINUE
C
C     DETERMINE SLOPE AND INTERCEPT OF EACH SEGMENT OF EACH BARRIER
C
      IF (IDB .EQ. 1)   GO TO 210
      DO 200  J=1,NBAR
      NNBAR = BAR(1,2*J-1)
      DO 200  K=2,NNBAR
      IF ((BAR(K+1,2*J-1)-BAR(K,2*J-1)) .EQ. 0.)  GO TO 200
      BSLOPE(K,2*J-1) = (BAR(K+1,2*J)-BAR(K,2*J))/
     1                  (BAR(K+1,2*J-1)-BAR(K,2*J-1))
      BSLOPE(K,2*J) = BAR(K,2*J)-BSLOPE(K,2*J-1)*BAR(K,2*J-1)
200   CONTINUE
      IDB = 1
C
C     DETERMINE INTERSECTION FUNCTIONS
C           IF VALUE OF INSECTION IS LE TO ZERO OR GE 1,
C           INCLUDE STATION.
```

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      C                                                                    BD0594
  210 DO 400  I=1,NPOS                                                     BD0595
      DO 375  J=1,NBAR                                                     BD0596
      NNBAR = BAR(1,2*J-1)                                                 BD0597
      DO 375  K=2,NNBAR                                                    BD0598
      IF ((BAR(K+1,2*J-1)-BAR(K,2*J-1)) .EQ. 0.)  GO TO 220                BD0599
      DENOM1 = BSLOPE(K,2*J-1)*(X-WPOS(I,1))-(Y-WPOS(I,2))                 BD0600
      IF (DENOM1 .EQ. 0.)   GO TO 350                                      BD0601
      ALPHA = (WPOS(I,2)-BSLOPE(K,2*J-1)*WPOS(I,1)-BSLOPE(K,2*J))/         BD0602
     &             DENOM1                                                  BD0603
      GO TO 240                                                            BD0604
  220 DENOM2 = X-WPOS(I,1)                                                 BD0605
      IF (DENOM2 .EQ. 0.)   GO TO 350                                      BD0606
      ALPHA = -WPOS(I,1)/DENOM2                                            BD0607
  240 IF (ALPHA .GE. 1.)  GO TO 350                                        BD0608
      IF (ALPHA .LE. 0.)  GO TO 350                                        BD0609
      IF ((WPOS(I,1)-X) .NE. 0.)  GO TO 250                                BD0610
      IF ((WPOS(I,2)-Y) .EQ. 0.)  GO TO 350                                BD0611
      GO TO 260                                                            BD0612
  250 DENOM3 = TSLOPE(I,1)*(BAR(K,2*J-1)-BAR(K+1,2*J-1))                   BD0613
     &             -BAR(K,2*J)+BAR(K+1,2*J)                                BD0614
      IF (DENOM3 .EQ. 0.)    GO TO 350                                     BD0615
      BETA = (BAR(K+1,2*J)-TSLOPE(I,1)*BAR(K+1,2*J-1)-TSLOPE(I,2))/        BD0616
     &             DENOM3                                                  BD0617
      GO TO 280                                                            BD0618
  260 DENOM4 = BAR(K,2*J-1)-BAR(K+1,2*J-1)                                 BD0619
      IF (DENOM4 .EQ. 0.)   GO TO 350                                      BD0620
      BETA = -BAR(K+1,2*J-1)/DENOM4                                        BD0621
  280 IF (BETA .GE. 1.)  GO TO 350                                         BD0622
      IF (BETA .LE. 0.)  GO TO 350                                         BD0623
      JBAR(I) = 0                                                          BD0624
      GO TO 400                                                            BD0625
  300 CONTINUE                                                             BD0626
      GO TO 400                                                            BD0627
  350 JBAR(I) = 1                                                          BD0628
  375 CONTINUE                                                             BD0629
  400 CONTINUE                                                             BD0630
      RETURN                                                               BD0631
      END                                                                  BD0632
```